PERIODICAL ROOM GENERAL LIBRARY UNIV. OF MICH.
JUN 11 1930

CAN WE SIGNAL TO MARS ?

DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. XI. No. 126. JUNE, 1930. PRICE 1s. NET

A CHARIOT BOY.

Statue discovered in the sea off Greece.

See page 202

CHIEF CONTENTS.

	Pages
In Search of White Rhino ...	179
Can We Signal to Mars ? ...	183
The Structure of Matter ...	187
Sheffield University To-day ...	190
Virus Diseases of Plants ...	195
Exploration from the Air ...	199
Statues Found in the Sea ...	202
Microscopic Art	204
Correspondence	207
A Lost Language	208
Book Reviews	209

PFURTSCHELLER'S

Zoological Wall Charts

(IN COLOURS)

The best collection of Charts in existence.

Eminently suitable for University Lectures and Secondary Schools. Artistic in design and at the same time clear in detail. Size 50 × 54 ins.

38 SUBJECTS. MOUNTED, WITH ROLLERS, 16s. each.

"Stand out admirably from a distance."—*Nature.*

Being the agents for Great Britain we hold stocks, and shall be pleased to send lists and full illustrated particulars.

FOYLES FOR BOOKS ON ALL SUBJECTS

This month's Special Offer—

Coloured Illustrations of British Birds and their Eggs.

By H. L. MEYER. Illustrated with 322 plates, mostly drawn by the author. 7 vols. 8vo. Bound in half red morocco, 1853-1857. A Set offered for £8 10s. 1 vol. sent on approval. Quote offer 52.

Deferred payments arranged (Gt. Britain only).

Authoritative Works on Birds.

Foyles are offering a number of Fine Sets, a list of which will be sent to anyone interested.

A GUIDE TO THE BEST BOOKS ON NATURE STUDY and a CLEARANCE LIST OF BOOKS ON ZOOLOGY will also be sent if desired.

卐 119-125 Charing Cross Road, London W.C.2. Gerrard 9310 (5 lines). Extension 3.

YOUR SUBSCRIPTION FREE!

Special Offer to "Discovery" Readers

To mark the completion of Benn's Sixpenny Library (which last month reached a total of 150 volumes), DISCOVERY has acquired a number of sets for sale to readers, with which a year's free subscription is offered. Every reader who buys a complete set of these books from DISCOVERY will receive twelve issues of the magazine without charge. Those who subscribe already will have their subscriptions extended free for twelve months.

The representative titles listed below indicate the wide range of subjects covered by the Sixpenny Library, which during the past three years has had a warm welcome among readers of DISCOVERY. Singly nearly 2,000,000 copies of these Sixpenny books have been sold in three years—averaging over 12,000 copies a week. An even greater demand is expected for the complete sets, which may now be purchased for the first time. The price is £3 15s. (*postage extra* 2s. 6d. inland, 6s. colonial and foreign), and the shelf space required for the books is only 2 ft. 6 in. *The order form must be accompanied by a remittance.*

HISTORY.

ENGLAND by D. C. Somervell.
SCOTLAND by R. S. Rait.
IRELAND by Sir James O'Connor.
WALES by J. E. Lloyd.
THE BRITISH EMPIRE by Douglas Woodruff.
THE BRITISH CONSTITUTION by Sir Sidney Low.
EUROPE by R. B. Mowat.
FRANCE by Sisley Huddleston.
GERMANY by W. H. Dawson.
RUSSIA by Prince Mirsky.
ITALY by Mrs. G. M. Trevelyan.
THE UNITED STATES by Robert McElroy.

ART and LITERATURE.

ARCHITECTURE by Christian Barman.
ENGLISH FURNITURE by Oliver Brackett.
HISTORY OF MUSIC by P. C. Buck.
OPERA by Richard Capell.
THE ENGLISH DRAMA by H. F. Rubinstein.
GREAT WRITERS OF ROME by R. S. Conway.
THE ENGLISH LANGUAGE by E. Weekley.
ITALIAN LITERATURE by Edmund Gardner.
RUSSIAN LITERATURE by J. Lavrin.
FRENCH LITERATURE by Maurice Baring.
GERMAN LITERATURE by G. Waterhouse.
THE ENGLISH NOVEL by J. B. Priestley.
LIFE OF CHRIST by Rev. R. J. Campbell.
SIR ISAAC NEWTON by V. E. Pullin.
CROMWELL by Hilaire Belloc.
NAPOLEON by J. Holland Rose.

ECONOMICS.

ECONOMICS by W. Henderson Pringle.
TRADE by Sir Ernest Benn.
MONEY by Hartley Withers.
BANKING by W. W. Paine.
RAILWAYS by Lord Monkswell.
ENGLISH EDUCATIONAL SYSTEM by Cyril Norwood.
LAW by J. E. G. de Montmorency.
POLITICAL IDEAS by F. J. C. Hearnshaw.
BRITISH UNIVERSITIES by Sir Charles Grant Robertson.
THE PRESS by Sir Alfred Robbins.
LIBRARIES AND MUSEUMS by Sir Frederic Kenyon.
SCOUTING AND YOUTH MOVEMENTS by Lord Baden-Powell.

SCIENCE.

MODERN SCIENTIFIC IDEAS by Sir Oliver Lodge.
MODERN PROBLEMS OF BIOLOGY by W. J. Dakin.
SCIENCE AND REALITY by R. A. Sampson.
ENERGY by Sir Oliver Lodge.
THE ATOM by E. N. da C. Andrade.
RELATIVITY by James Rice.
ZOOLOGY by J. Graham Kerr.
BOTANY by S. Mangham.
EVOLUTION by E. W. MacBride.
HEREDITY by F. A. E. Crew.
AGE OF THE EARTH by Arthur Holmes.
GEOGRAPHY by H. J. Fleure.
FUEL by Sir Richard Redmayne.
CHEMISTRY by Percy Spielmann.

This Order Form must be used.

To THE MANAGER, *DISCOVERY*,
154, FLEET ST., E.C.4.

Please send me a complete set of Benn Sixpenny Library, for which I enclose £ : : (including postage). This entitles me to receive "Discovery" for twelve months without charge.

Name .....

Address .....

Date .....

DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. XI. No. 126 JUNE, 1930. PRICE 1s. NET

Trustees: Sir J. J. Thomson, O.M., F.R.S., Sir F. G. Kenyon, K.C.B., F.B.A., Professor A. C. Seward, Sc.D., F.R.S., Professor R. S. Conway, Litt.D., F.B.A.

Edited by John A. Benn.

Publishers: Benn Brothers, Ltd. All communications respecting editorial matters to be addressed to the Editor; all questions of advertisements and subscriptions to the Manager.

Offices: Bouverie House, Fleet Street, London, E.C.4. (Closed on Saturday.)

Telephone City 0244. Telegrams: Benbrolish, Fleet, London.

Annual Subscription, 12*s.* 6*d.* post free anywhere in the world. Single numbers, 1*s.* net; single back numbers more than two years old, 1*s.* 6*d.* net: postage 2*d.*

Binding cases, price 2*s.* 6*d.* net each; postage 6*d.*

Editorial Notes.

Six months ago, introducing the new articles on British universities, we expressed the hope that they would do something to dispel the misunderstanding between the old and the modern universities, which still exists in certain quarters. We did not disguise our misgivings lest our contributors should fail in the very difficult task before them. The six articles that have so far appeared, including this month's account of Sheffield University, have fulfilled our every hope for the series, which is providing statements of the highest value to education and to all concerned with the future of national life. The lack of up-to-date information on university policy has been stressed time and again in recent pronouncements, and the writers in *Discovery* are performing a public service. It would be invidious to comment on the relative merits of the articles so far published; all have maintained the high level set by one of our Trustees in the opening article on Cambridge. Two conclusions clearly emerge from the series. On the one hand the vocational aspects of education are everywhere receiving belated attention, on the other hand liberal studies still have pride of place in all our universities. The greatest problem confronting education is to blend these factors, so as to create a proper harmony between what may very broadly be termed "commerce and culture." There are welcome signs of progress on every hand, most of all in the wide insistence on learning for its own sake. Striking evidence is advanced by Sir Henry Hadow on the popularity of the arts and pure science at Sheffield, which at the same time can boast one of the finest applied science departments in the country. Those who still think that there is a great gulf fixed between certain British universities will be disillusioned before many years are past. Industrial civilization is as yet in its infancy, and the problems of the new era are common to them all.

* * * * *

A plea for excavations on the site of Corfinium has been made to the Italian Government by Professor Conway. The proposed object is to search for further evidence of a primitive language, so far known only from a few inscriptions discovered some fifty years ago. From the letter which we reproduce on another page, it will be seen that the lost language should afford interesting material for study. It was still spoken in the time of Caesar, and its discovery would throw valuable light not only on Latin itself but on the Indo-European languages generally. Unlike certain ancient sites that are buried under volcanic ash or modern buildings, the site of Corfinium lies in the Apennine hills. Its excavation would therefore involve no difficulty, beyond disturbing a few fields of soil now under cultivation. The importance of the proposal is obvious to all students of language, and its author has offered to assist personally in carrying it out. The Fascist Government has already done much for archaeological research, and we feel confident that Professor Conway's request in the name of international science will not remain unheard.

* * * * *

Preliminary plans are now issued for the British Association meeting, which will take place this year in Bristol. The presidential address will be delivered on 3rd September by Professor F. O. Bower, who has chosen to speak on "Size and Form in Plants." The occasion will be the fourth on which Bristol has received the Association. The first was in 1836 under the presidency of Lord Northampton, who took the opportunity to lay the first stone of the well-known suspension bridge. Another historical event was the

cutting then in progress for the Great Western Railway, which afforded members unusual opportunities to study the geology of the district. In spite of such evidence of progress, however, a pronouncement was made at the meeting which proved to be singularly mistaken. Dr. Lardner said that it would not be possible for a steamship to carry enough coal to allow it to cross the Atlantic! Since those early days Bristol has gained a great attraction in its university, whose buildings are the most beautiful of their kind in England. Our British Association Number (September) will include an article on Bristol University—the next article in this series, which we are suspending during the summer vacation.

* * * * *

We are indebted to Mr. Stanley Casson for sending us the first photographs of some remarkable statues, which were found in the sea off the Greek coast and are now on view in the National Museum at Athens. The discovery has a romantic story. A few years ago some fishermen found obstructions in their net, which proved to be parts of a bronze statue. Later on a thorough search was made and the remaining pieces were recovered. Fortunately the metal has suffered no damage from its long immersion in the water. When mended and restored the statue proved to be a masterpiece of art—as Mr. Casson says, "the finest representation of any Greek god by Greek hands." Various suggestions have been made by scholars as to its identity, one of them being that it represents Poseidon wielding his trident. In Mr. Casson's opinion, however, now that the statue is restored, the features are clearly those of the Father of the Gods. A second discovery is a statue of a boy, which was part of a chariot group. His resemblance to the urchins of modern Athens, who sit on the mudguards of motor-cars, is an interesting commentary on unchanging youth.

* * * * *

Half a century ago, when the conflict between science and theology first attracted wide notice, it seemed as if biological discovery had destroyed the value of the Bible as evidence. Now the pendulum has swung the other way. Almost every year fresh material is brought to light, confirming that even the most legendary parts of the Old Testament may have an historical basis. To this end Mr. Woolley's excavations at Ur have notably contributed. But the subject has many difficulties, as Professor Garstang showed in a lecture last month at the Royal Institution. Special caution is demanded, together with a tolerant and commonsense attitude, if the truth is to be discovered. Work in Palestine since the war has thrown light particularly upon the period of *Joshua* and *Judges*. There is now no reason to doubt that the traditions embodied in the old documentary sources (J and E) of both Books were founded on fact. The archaeology of the later documents (D and P) is a more complex study, which will involve further years of active research.

* * * * *

We regret to record the death of Herr Max Valier, the German rocket expert, who was killed last month by an explosion. Ever since he first contributed to *Discovery* in June, 1926, he was a persistent advocate of flying by rocket, and last year a rival—Herr von Opel—succeeded in travelling a mile in a rocket aeroplane. Valier's own work was undoubtedly hampered by lack of finance, but he made a spectacular speed attempt in a rocket-sled and claimed to have established a world record. Thousands of spectators collected on the ice at Lake Starnberg, where it was estimated that the sled attained the remarkable speed of 249 miles an hour—twenty miles greater than the motoring record held at that time by Sir Henry Segrave. Though his writings were highly speculative and dealt mainly with inter-planetary flight, Max Valier based them on small-scale experiments. The wide interest in the subject is a tribute to his work. Its latest adherent is Professor Stewart, the well-known American astronomer, who recently proposed plans for sending a cannon-ball to the moon.

* * * * *

A remarkable innovation in the reception of speeches at international gatherings is to be tried out at the second World Power Conference in Berlin this month. It will be possible to follow addresses and discussions in any of the three official languages of the conference—English, German, or French—no matter which of these languages is being used by the speaker. Placed in front of each seat in the auditorium is a pair of head-phones, connected to a specially designed switchbox, by means of which the listener can switch on to the language he best understands. The speakers and the interpreters, who translate on the spot, all speak into microphones equipped with sound-proof mouthpieces. To allow two interpreters to relieve each other without interruption, two microphones are connected in parallel. The speech-currents are transmitted to an amplifier and thence to the listeners' apparatus. In order to show which language the lecturer himself is using, an indicator is arranged behind the rostrum, with coloured lamps that light up for this purpose. Over three miles of double wiring is necessary for connecting the thousand members' places to the platform.

In Search of White Rhino.

By Paul L. Hoefler.

Leader of the Colorado African Expedition.

Some American explorers have just returned from Uganda, where they made important observations of the rare white rhinoceros. During the journey some new facts were obtained about the local native tribes.

WHERE the River Nile flows as a sluggish stream between wide expanses of papyrus swamp, and the sun pours down a deadly heat, there still exist in a small area a few white rhinoceros, the third largest of living land mammals. The government of Uganda and those who administer the affairs of the West Nile Province are not very keen to allow anyone to enter the district where this rare beast has its sanctuary. When they do give permission, it is only with the understanding that none of the rhino will be harmed under any circumstances. Having assured them on this score, I was allowed to take my party out in search of the animal, in order that photographs might be obtained. The route was so arranged that while travelling to the west coast the course took us near their haunts.

After motoring across Uganda to Butiaba on the eastern shore of Lake Albert, we loaded the two trucks on board a lighter, which was towed behind the good ship *Samuel Baker* to the western side, to a place marked on some maps as Mahaji Port. Not long afterwards the ship was tied alongside the river boat *Lugard*, to which all our goods were transferred. This boat is built for shallow water, only requiring two feet to keep it afloat. Next morning the river had narrowed, and thousands of white ibis flew about and covered the trees on shore like white blossoms. A family of hippo disported itself near the bank, and we also observed some elephants.

Transport Troubles.

We landed the trucks and ourselves at Pa'.wach, this place being twice the size of Mahaji Port, boasting two grass huts! As each truck came off the lighter it punched a hole in the pier, but this was nothing to what happened later, for we went through each and every culvert on the road to Arua, some hundred and twenty miles distant. We stopped the first night at Ngal, and the next day proved to be one of the hardest of the expedition, for from sunrise to sunset our total mileage was ten and one half. There were five bridges to cross, not regular bridges but logs thrown across rivers, upheld by forked limbs and surfaced with bamboo.

We made an inspection of each bridge as we came to it, and found it necessary to unload everything from the trucks and run them over empty. Luckily for us, as soon as the trucks stopped, a crowd of natives would appear almost at once, and these we would put to work carrying the loads to the other side. These Alulu people are good workers and would run with the loads, seeming to enjoy it greatly. As I watched the women carry big loads on their heads, I could not but wonder what they would think of the easy life led by the average American housewife, who sometimes complains if she has to get her husband an early breakfast! Two of these bridges were over fifty feet high and two hundred feet long, and to lessen the chances of an accident, we hauled the lorries over with a long rope pulled by a hundred natives.

Native Customs.

After this arduous day we were thankful to reach the village of Nebbi and make camp for the night. Here I sent for the sultan as I wanted to learn something about his people. He came at once and proved to be a fine young man, with strong features, a pleasant manner and broad smile. His name was Gelasega, he being the son of Sultan Amula, the paramount ruler of the Alulu tribe, who holds his court at Okaro. I served him with tea, and then as he spoke Swahili fluently, I was able to get first-hand information about this strange and little known people. The country of the Alulu covers that large area extending from the west bank of the River Nile into the high hills near Okollo, and I was assured that his people were very old, that they had lived in this country since the early time of man. What a history must be theirs!—a history, however, lost in the dust of ages, for try as he would this young sultan could tell no tale of the past that rang true, so I found it necessary to confine myself to the present.

The most noticeable thing about this tribe was that while the men wore a scanty bit of cloth or skin, the women were naked. In other parts of this dark continent I had gazed upon naked men by the thousands, but this was the first time that naked women had come under my observation. Their only covering was a small bunch of grass hung from a

TRANSPORT TROUBLES.

The bridges from Pakwach to Arua were so bad that the lorry travelled only ten miles in a day. Unloading was usually necessary.

string round the waist. The Alulu tribe, like their neighbours, the Lugwari, prohibit their women to wear anything that will hide the body. When I asked their chief about this custom, he replied that their women had always gone so; that it was best for their health. A man was stronger and could take a chance of clothing breaking down his health, besides, there was only one man in a family to buy clothing for, but each man had many wives, and it would ruin him if he had to buy clothes for all of them!

The marriage customs of different African tribes are always interesting, each tribe having some peculiar custom of its own. Among the Alulu, as among many other tribes, the woman is considered a valuable piece of property, a thing to be bargained over, to be sold and traded, to be used as a beast of burden, having no rights and no privileges.* Girls are married off by their fathers at from twelve to fourteen years of age, the girl having nothing to say in the matter. The father sells where he can get the best price. If he can sell to a rich man he may get as many as six oxen for her, while if he finds it necessary to sell to a poor man the best he can expect is two oxen for the same girl. Cattle is the money of the country, on which all value is based. Each man has as many wives as he can afford to buy, for the more women he has, the more children he can raise, the girls to sell, and the boys to work for him until their marriage; while the women, of course, in addition to bearing many children, do all the hard labour.

The father of a boy helps him to buy his first wife, which amounts to the same thing as a civilized father placing his son in business. He must earn the others for himself, and his success in life is measured by the number of wives he leaves to mourn his passing. When a husband dies, his wives, along with his cattle and other property, go to his eldest brother, who adds them to his list of assets. If the widows do not like their new husband, they can select some other man, who can get them by paying to the new owner their list price in cattle. Middle-aged and old widows bring a very small price, and sometimes the eldest brother who falls heir to an odd lot of old wives feels unkindly toward his late of kin.

As we passed through the villages of Paida, Neapea, Zeio, Warr, Kango and Logiri, the entire population would turn out and cheer us as the strange wagons roared by. At Arua I went to see the British official in charge of the district, and his first question was as to the route we had come. When I replied "from Pakwach" he was more than surprised, and asked how many bridges we had wrecked! It seems that we were the first ever to land at Pakwach and motor to Arua, the bridges being built for foot *safaris*.

Forty-two miles by road brought us again to the Nile, and there we camped close to its shore. On the opposite side a huge papyrus swamp stretches to the distant horizon, a swamp that teems with poisonous reptiles and all orders of things which love the dark and the damp. On our side of the Nile live the white rhino—those rare and strange beasts left over from the long ago, from the age when all the animals of the earth were weird of form and armed for battle. It was with a feeling that I had been transported back into the age of flying reptiles and sabre-toothed tigers that I followed the little negro who strode in front of me, as the little party wound

LUGWARI NATIVES.

Crowd assembled on the quay at Mahaji Port. This tribe, like its neighbours the Alulu, preserves many customs of great interest.

* "Sold" is perhaps misleading. The "bride-price" ratifies the marriage and determines the status of the wife and her children. It is a pledge or bond between social groups into which, however, the economic factor also enters.—ED., *Discovery*.

WHITE RHINOCEROS AT CLOSE RANGE.

The colour of the skin is pale reddish-brown, which appears white in certain lights, hence the name of this species. The horns are long and slim, the front horn being the longest, and owing to the square mouth and jaw the width of the face appears to be enormous.

its way through the tall grass, over a landscape which fits into the mental picture perfectly.

No matter in what country you hunt rhino, it is always the same story of weary miles under a scorching sun, for all members of this family seem to pick the hardest and most trying country for their haunts. Mile after mile we walked, and soon I was dripping with perspiration, but just as I felt inclined to call a short halt, the boy ahead stopped still and pointed to a clump of small trees. Coming up to him I made out two light-coloured shapes standing in the shade, moving slightly as I looked, thus proving that they were not ant hills, like the many "rhino" we had already seen. This cow and calf must have got a whiff of us, for they were very shy and gave us a hard half-hour's work in attempting to photograph them, the whole effort resulting in one negative and no moving pictures at all, or at least none worth bragging about.

When the animals shifted and got into the open, so that a good view was had of them, we appreciated for the first time their tremendous bulk. The cow loomed over the calf like an ocean liner over a tug boat, and it was big enough to attract attention in any company, even though it was only half grown. As J—— and I stalked them with cameras, rushing here and there to get into a position where a good picture could be taken, our two gun-boys tried their best to keep close at hand. But twice when the cow lost her temper and snorted in our direction the boys made short work of getting into a high perch, leaving us without guns and too tired to run. The cow kept circling until she got our wind, and then with a loud snort kicked up her heels and made tracks too fast for us to follow. The calf also made tracks, sometimes getting in its mother's way, only to be pushed almost off its feet. Upon regaining its equilibrium it would make a frantic start, then soon overtake its mother, and so they disappeared from sight.

Things had happened so fast, and I was so keen to get pictures, that I had little time to make notes of the animal itself, so we started in search of more white rhino, taking a long circle toward camp, which would carry us near the Nile. We came upon many water-buck but no rhino. There was still about two hours of daylight left, so J—— took my heavy rifle and some boys with him, going along the Nile bank in the opposite direction from which we had just come. He found a place only a short distance away that was teeming with buck, while buffalo were plentiful. Wounding a buffalo bull, he started in pursuit, and then had an experience that is interesting as proving how little is known about the distribution of some African animals. We had been assured by several men, who undoubtedly thought they knew the facts, that there were no common, or black, rhino in the district inhabited by the white rhino.

The wounded buffalo ran over the brow of a small hill with J—— chasing it behind. As he neared the crest of the hill, an ugly black snout appeared and he raised his rifle to fire, thinking it to be the buffalo. He discovered his mistake just in time to save shooting

a big black rhino bull, who had heard him coming and was anxious to greet whatever came over the hill. Back-tracking to windward of this beast, he gained a point of vantage and found that Mr. Rhino was guarding a female and a small calf. Here was a whole family of black rhino in a country supposed to be inhabited solely by the white representative of the species!

Early next morning we again went in search of the white rhino, and this time were successful beyond all expectations. An hour's walk brought us to a place where some rhino had wallowed that night, so taking their spoor we tracked them over hill and dale until I had just about reached my melting point. It was impossible to make out how many animals were ahead of us, for the tracks would branch off and then join up again, then all would walk almost in the same foot-prints. In far less mileage than we had covered on the previous occasion we came upon them. Gathering the party together into a compact group, the cameras were made ready for action, and with two boys to carry the big movie outfit, and one gun-bearer for any emergency that might arise, J—— and I crept slowly toward them.

Now both of us had stalked the black rhino and I had filmed more than one of these truculent creatures, but this was a different animal, and the surprise and thrill that awaited us round the corner of a small bush is impossible to describe. There stood not two but five huge beasts, one of which would tower over a black rhino like the Woolworth Building over Trinity Church! How many tons of flesh were represented there I cannot state, but this mammoth pachyderm gave me a good reason to look around to see if the gun-bearer was close at hand. He was not!

A Close View.

The bull stood broadside on, a mountain of flesh and bone, the profile of head and horns outlined against the sky in such a way as to be more impressive than if seen against a background of trees. The animals had no suspicion of our being there, and went on feeding and nosing about. Placing the camera in position I began to grind away, and as I did, had the time to take a few mental notes. These rhino are not white, but might appear so in certain light. The actual colour is a light reddish-brown. The horns are very long and quite slim, the front horn being the longest in all cases—how long I would not care to guess, but the record horn for a white rhino cow is over sixty-two inches Its muzzle was truncated and had no prehensile tip, this explaining why it is sometimes referred to as the square-lipped rhinoceros. The skull has great length, and when it turned and faced me I could not but remark on the enormous width of its face, caused by the square mouth and flat front surface of the horn.

The animal walked slowly to within thirty yards, its head carried low, and then must have heard the clicking of the camera, for he moved away, to be followed by seven more! We got the whole bunch as they crossed the screen one behind the other, a picture of white rhino that will take a lot to beat.

Risky Moments.

After this scene we filmed the animals for some three hours, from many different positions, and in so doing took considerable risks. For although their vision is poor and their hearing not so good, they have a marvellously keen scent, and as the wind was somewhat gusty and often veered about, it kept us busy keeping to their windward. Once the wind suddenly changed and placed us in a rather uncomfortable position. We were almost surrounded by the eight rhino, when a whiff of air carried knowledge of our presence to a cow with calf. She turned on us and snorted, then made a short dash forward and things looked nasty for a while. Behind us, within forty yards, stood three of the group, two more were close to hand on our right, while the big bull was eyeing us fifty paces to our left. Had the cow charged it would have been hard to decide which way to run!

We followed a young bull trying to get some real "close-ups," until he got peeved at our persistence and charged us. It came as a complete surprise, for we had by now got quite used to the rhino and had lost all fear, so there was a mad scramble for a while. The rhino had all the advantage, for in a hand-to-hand battle he would have won hands down, while we could not shoot no matter if he did charge. As he rushed toward my four-thousand-dollar camera, I forgot all else and tried to attract his attention to myself, at the same time looking about for a suitable tree. He came about half-way, then showed some hesitation, and just at this point J—— got hold of his gun and fired a shot into the air. The report frightened the beast and away he went, this time in the proper direction for a charging rhino!

Well satisfied with the day and thankful that nobody had been hurt, we trekked back to our camp on the Nile. There we discussed white rhino and its probable fate under any government other than that which now protects it, and all agreed that it should continue to be protected; for although a formidable beast and well able to hold its own against any opponent in the animal kingdom, it would soon vanish under the gunfire of the modern hunter.

Can We Signal to the Planets ?

By John Thomson, M.A., B.Sc., Ph.D.

Lecturer in Physics in the University of Reading.

The mechanical aspects of signalling to Mars were discussed in an editorial note last month. A contributor now surveys the problem as a whole, and concludes that it lies on the borderline of the practicable which many important inventions have but recently crossed. The possibilities are fascinating.

FROM time to time during the last fifty years suggestions have been made for sending a message to a neighbouring planet. In general these suggestions have been scientifically worthless, but for all that the possibility merits consideration. At the lowest estimate a general airing of the question seems to be required, while an accurate statement of the problem and its difficulties is the first step towards any attack which may be made upon it. The question divides itself naturally into three parts. First, can we send a signal through space so that it may be detected on a companion world? Second, in the event of our being able to do so, is there any possibility of the signal being received and understood? Third, having regard to our answers to the previous questions, what signal would we send?

Difficulties.

To illustrate the difficulties involved, let us consider the possibility of utilizing some form of televisor. In the May *Discovery*, mention was made of this means of signalling, and the conclusion rightly reached was that "the prospects of finding planetary neighbours equipped with the necessary apparatus are remote." The complete televisor consists of a transmitter and receiver. The signal propagated through space is, of course, an electro-magnetic disturbance, but this disturbance is obtained at the transmitter from light signals by a series of ingenious energy transformations. Similarly, the receiver, working on the same wave-length, must be able to transform back the electro-magnetic impulse into light signals. Such a process is very complicated and presupposes a vast amount of technical apparatus. But, as will be shown later, in communicating with another planet it is not permissable to assume the existence of *any* equipment similar to that which we use. The best we can hope for is that our planetary neighbours are aware of the existence of the electro-magnetic spectrum and possess *some* means of detecting electro-magnetic impulses.

There is another objection to visual signalling of an even more fundamental nature. It is probable that the possible inhabitants of another planet react in some way to light signals; this appears to be a necessity for intelligent life. To suppose, however, that this reaction corresponds to our own visual sensations is pure speculation. Assuming that a television receiver existed on the planet under consideration, the picture formed on the screen would in all probability convey nothing to the inhabitants.

Simplicity Essential.

Hence a scientific approach to the problem demands a form of signal much simpler and more fundamental. Since we are attempting to communicate from the earth to another planet, and between them no material medium exists, it is at once evident that we must utilize as our signal some form of radiation which is transmitted by a vacuum. This is practically equivalent to saying that we must use some part of the "electro-magnetic" spectrum. But even a casual examination of the problem is sufficient to indicate that our choice of such radiation is extremely limited.

The mere fact that the solid earth is surrounded by an atmosphere capable of absorbing *all* radiation to a greater or less degree makes our choice a difficult one, while the problem of producing radiation of intensity sufficient to be detected some millions of miles away so far adds to this difficulty that we shall be fortunate to find *any* type of signal suitable for our purpose. Atmospheric absorption immediately rules out of consideration radiation of short wave-length, since X-rays and ultra-violet rays are strongly absorbed by gases. Light and heat radiation do not suffer in this way, but these, as we shall see, are useless for a very different reason. Hertzian waves have been carefully studied in recent years so far as their propagation round the earth is concerned, and it is to such radiation that we must look most hopefully.

Fig. 1 indicates the relative positions of the Earth, Venus, Mars and the Sun when conditions would apparently be most favourable for communication between the three planets. The figure corresponds to what is known as an "opposition" of Mars and

an "inferior conjunction" of Venus. It is at such an epoch that these two planets are nearest to the Earth. Mars is then on the meridian approximately at midnight, while Venus is (along with the Sun) on the meridian at midday. It is instructive to notice that under these conditions the appearance of Venus from the Earth is similar to the appearance of the Earth from Mars, while the appearance of Mars from the Earth is similar to the appearance of the Earth from Venus. It is useful to realize the point of view of the possible recipients of our signal.

Now we cannot hope in signalling to compete with the Sun. If the Sun is sending out radiation similar to the one we might choose, then our signal will go undetected. A consideration of Fig. 1 will make this perfectly clear. But the Sun is continually radiating light and heat, and therefore these signals, as has been stated, may be left out of consideration.

It is obvious then that our attention must be limited to a consideration of Hertzian waves, the type of radiation propagated from a broadcasting station. At the very outset, however, we meet with a serious difficulty. Various writers on wireless communication have described it as "signalling through space," and so far as space is interplanetary, this is just what a broadcasting station does not do. One of the chief reasons why Hertzian waves have become an important means of communication over long distances is that the transmitted signals are confined to a comparatively narrow layer of space in the immediate vicinity of the Earth. The signals broadcast do not spread out in all directions; they travel round the Earth practically never rising beyond the limits of the atmosphere.

Fig. 2 gives a rough representation of the path of a "wireless" ray from a radio transmitter T. The ray may move upwards towards a layer of ionized gas known as the "Heaviside layer," but there it is bent downwards again towards the Earth. A straight beam from the transmitter parallel to the horizon is indicated by the dotted line. It will be seen that the latter could not possibly be detected at any distance from the station, as it would be lost in the upper atmosphere.

This bending of Hertzian waves due to refraction (or possibly in some cases to reflection) is of inestimable value in wireless signalling, and accounts for the remarkably long distances traversed by waves over the surface of the Earth, but from the point of view of interplanetary communication the Heaviside layer is an unmitigated nuisance, cutting us off, as it does, from outer space. All Hertzian waves are not, however, equally affected in this way, the bending of the ray varying considerably with its wave-length, and hence it may be possible to find some band of waves which may escape to outer space. Recent experiments appear to suggest that short waves are less bent than long waves, and this is in agreement with the most important theory of the effect. It is probably impossible to produce Hertzian radiation which will traverse the atmosphere in an even approximately straight line, but if the wave-length is sufficiently short, there is a reasonable expectation that the deviation of the ray will be comparatively unimportant. Such radiation has a wave-length of less than ten metres.

Attacking the problem from another point of view, an alternative solution is indicated. Theoretically the use of waves of length greater than ten thousand metres should also obviate absorption and refraction in a layer of ionized gas.

Two possible bands of radiation would therefore appear to be suitable for the penetration of the Earth's atmosphere, and we have now to determine which band is more suitable for our purpose in other ways. The question of the intensity of the signal decides, as we shall see, in favour of the short waves. Incidentally, it is useful to note, before we leave this part of the subject, that any radiation which can penetrate

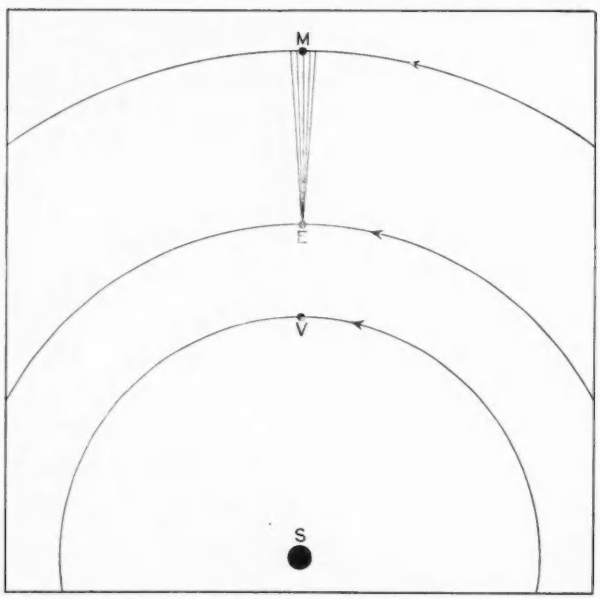


FIG. 1.
DIAGRAM SHOWING RELATIVE POSITIONS OF PLANETS.

our atmosphere will be suitable to penetrate the atmosphere of the receiving planet.

We have said that it is preferable to use a radiation of short wave-length. This arises from the fact that in any attempt to signal over a distance of millions of miles some form of beam is necessary, since, if the radiation were distributed uniformly in all directions, that the requisite intensity could not be obtained at our present stage of development, the problem is merely one of technique. The wireless engineers are quite capable of producing as intense a beam as we may require when the need for it should arise. The directing of the beam, making allowance for refraction in the upper atmosphere, would be much more difficult.

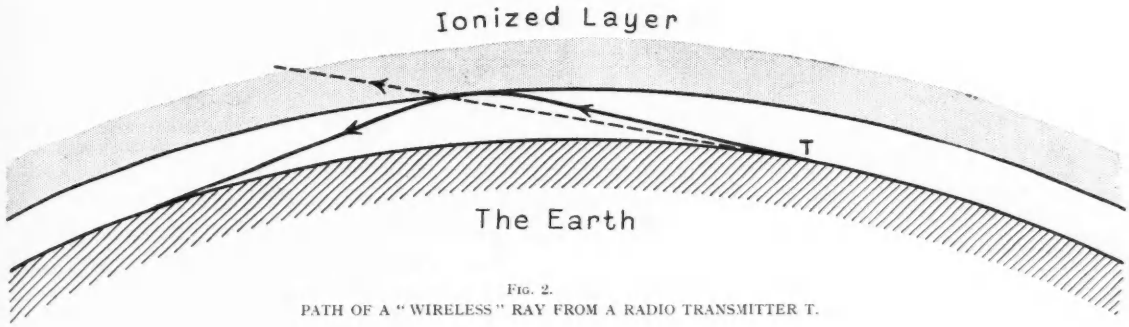


FIG. 2.
PATH OF A "WIRELESS" RAY FROM A RADIO TRANSMITTER T.

a perfectly negligible fraction would reach the planet. Now the concentration of Hertzian waves in the form of a beam necessitates the use of a reasonably short wave-length in order that the focussing may be efficient. Hence this is sufficient to decide between the rival claims put forward above.

Having decided on the type of radiation to be used, all that remains is to ask if a signal of intensity sufficient to be detected can be sent. The answer to this question must necessarily be speculative, for, in the first place, we are not acquainted with any receiving apparatus which the other planet may possess. The signal emitted by our transmitter will suffer attenuation because of two factors. First, the spreading of the beam will decrease its energy per unit area. Secondly, the atmosphere of the Earth and the other planet will be the cause of a certain amount of absorption. The spreading of the beam is an unfortunate necessity. By modern methods the pencil of rays could be made very fine indeed, and spreading (except that due to dispersion) could be avoided. But our aim at the planet cannot but be very rough, and hence a very fine beam would be almost sure to be lost in space. In Fig. 1 a pencil of rays is drawn from the Earth to Mars. The pencil shown diverges much more than would be necessary, but in any case its cross-sectional area on arriving at the orbit of the outer planet would require to be at least one thousand million square miles, in order that there should be a reasonable probability of the planet coming within it.

The sending of a very powerful short-wave signal is not, however, a very serious matter. Even assuming

Assuming then that we are able to *send* a signal, what can be said of the probability of its being received? Many writers have discussed the possibility of there being intelligent life on other planets, and it must be borne in mind that the whole subject is purely speculative. It does not follow, however, that our speculations are irrational or idle. The modern physicist deals largely and with great success in probabilities!

From a philosophic standpoint it appears improbable that the Earth is the only planet in the solar system which is the abode of intelligent life. Apart from all biological considerations, this makes an appeal to our philosophic instincts; anything else would savour of Ptolmaic egoism. Moreover, it is utterly impossible to argue that the other planets are *unsuited* for intelligent life, as has been done so often. Such an argument is founded on the assumption that protoplasm is an ultimate essential of life, while there is nothing to show that it is not the essential of life modified by terrestrial conditions. Even assuming that Martian or Venusian protoplasm would be identical with the terrestrial substance, there is still no sufficient evidence to state that life is impossible on these planets, and, where life is possible, intelligent life is probable.

A more important and less speculative question is whether the intelligent life on another planet would be able to detect and understand the significance of a Hertzian wave signal. We must not transfer our own form of intelligence to Mars or Venus, and assume that natural science has been "studied" by intelligencies there. We must remember that intelligent

*

beings existed on the Earth for some considerable time before any violent interest was taken by them in the phenomena of nature. However, if we assume on the part of these other beings a speculative and experimental interest in the material universe, then we may legitimately hope for some means of detection of short Hertzian waves. After all, the mechanism of the universe is not terrestrial, and whatever we may think of our *conception* of Hertzian waves, the waves themselves are common to all space. The reactions of intelligent life on Venus or Mars to material things must necessarily be different from ours, but the reactions must exist, and they will be reactions to phenomena similar to those we experience.

Obviously, of course, the Martian observer will not " listen-in " by means of the mechanism which we employ, and equally obviously the connotation he may give to the signal is beyond our comprehension. At the very best the evolution of an intelligent life on Mars will have followed quite different lines from our own. The accidents of environment will have produced mental processes of which we can know nothing. Indeed, our very terminology with regard to possible inhabitants of another planet will have a wider meaning than the one which we usually assign to it. How far are we justified, for example, in speaking of the " mental processes " of such beings? Yet it must again be urged that the Martian reactions will be reactions towards phenomena similar to those which we experience.

Finally, we must consider what signal we are to send. Here we encounter difficulties quite different from those already discussed. Speaking generally, our message must abstract from human thought and endeavour something which we consider might be recognized as a message from terrestrial intelligence. It would be useless, for example, sending a message in the English language to a French savant, no matter how intelligent he might be, if he did not understand our tongue.

Call Signs.

The only ray of hope is our belief that abstract scientific conceptions have a universal foundation in nature. The Earth is the third planet in the solar system. No matter how the non-terrestrial intelligence acts, a sequence of three impulses must convey some notion of the number three. Therefore it might be suggested that a beginning should be made in our communication by sending a systematic series of three distinct impulses. We can form no conception of how the Martian inhabitant thinks " three," but it appears probable that our signal would be of a sufficiently fundamental type to cause the requisite mental reaction. If on any occasion it was discovered that signals on the same wave-length were being received consisting of four impulses, we might have some reason to believe that an answer to our signal was being transmitted from Mars. We might, under these circumstances, describe " three " and " four " as the interplanetary call signs.

Limited Messages.

It may be objected that the suggested message is too simple, and that surely another, conveying more intelligence, could be devised. An eminent astronomer, discussing the possibility of life on the Moon, once suggested a signal to our satellite taking the form of a drawing on the surface of the Earth of the requisite dimensions of a right-angled triangle. He argued that this triangle, being of fundamental importance in geometry, would indicate to the possible inhabitants of the Moon the existence of intelligent life on the Earth. Leaving out of account the fact that Euclidean geometry is but a first approximation to the geometry of real space, did the astronomer not credit the Lunar intelligence with too terrestrial an origin? To imagine that the right-angled triangle, itself a mathematical abstraction, is common to all space, is surely like blaming an Englishman for not speaking Chinese! No! So far as inter-planetary communication is concerned, we are strictly limited in our messages to signals of universal nature.

Now that we have considered the various aspects of the problem, we ought to be in a position to say whether the possibility of communicating with our neighbouring planets comes into the realm of practical experiment. With regard to our means of sending a message, we have seen that we can hardly be sure that we possess the necessary equipment for making the attempt. On the other hand, researches at present in progress on the electrical structure of the upper atmosphere ought to provide the knowledge of refraction and absorption of short Hertzian waves which we require. Assuming that we can send the signal, whether it will be received or not is a matter of speculation, but we can at least be certain that there is no *a priori* reason why it should not. In any case, the only messages which we can send with a reasonable expectation of their conveying the impression of being signals from the Earth are of a very simple and uninteresting nature. Yet the possibility cannot be dismissed as a scientific fancy. It lies on that borderline of the practicable which so many of our most important inventions and discoveries have but recently crossed.

More about the Structure of Matter.

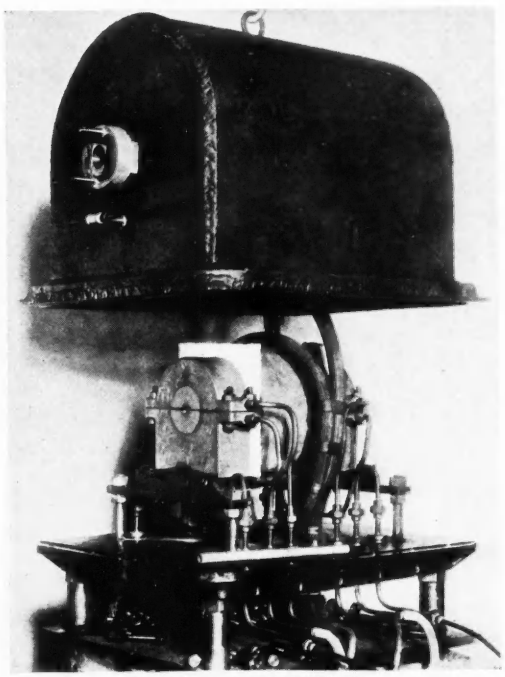
Among the notable achievements of American science in 1929 *was a discovery relating to carbon and oxygen, two of the most abundant elements of which the universe is composed. The work was undertaken at the famous Mount Wilson Observatory, and is here described from a report issued last month.*

STUDENTS of chemistry twenty-five years ago could safely base their conclusions on certain "facts." The most elementary was that matter consisted of about ninety elements, these in turn being composed of molecules and atoms. "The atom," one wrote for the examiner, "is the ultimate particle of matter which cannot be further divided." Then came the discovery that a certain element—neon—contained two kinds of atoms, each kind differing from the other in weight, and the previously simple scheme was complicated by "isotopes," the name coined for such atoms by Professor Soddy. (Greek: *isos*, the same; *topos*, place.)

Since the war the problem has been intensively studied, and by 1926 it was discovered that no fewer than thirty-one elements exhibit this phenomenon. Of the remainder it was thought that, with helium, carbon and hydrogen were the least likely to exist as "isotopes." Now, however, it is announced that even these die-hards must be classed in more than one form. The discovery was made in America at Mount Wilson Observatory (Carnegie Institution) and is of great importance to the progress of physics and chemistry. The observatory staff, directed by Dr. Walter Adams, was assisted in the work by members of California University, notably Professor Raymond Birge.

The new work was a continuation of research begun as early as 1910 when Professor Soddy revived a suggestion, made years before by Sir William Crookes, that some of the elements might be composed of atoms which were not alike in all respects. Soon afterward Sir J. J. Thomson (a Trustee of *Discovery*) invented a remarkable method known as "positive-ray analysis," by which he showed that the rare element called neon contains two kinds of atoms. The war interrupted investigation for a time, but in 1919 it was resumed. Soon afterwards Dr. F. W. Aston of Cambridge University and others, employing an improved form of Thomson's method, showed that many of the elements are really mixtures of two or more kinds of atoms and that neon was by no means an isolated case. Xenon, for example, was found to comprise a mixture of atoms having nine different weights, while several elements, mercury, cadmium, tin, and others, contained six or more kinds.

Until 1929, the elements that had failed to respond to tests for isotopes included, notably, oxygen and hydrogen. Recently, however, a method of analysis by means of *band spectra* has been developed, more searching than any formerly employed. After application to chlorine, boron, silicon, and copper (applications which revealed the presence of isotopes in each), the American investigators took up the method and applied it to these die-hard elements. The tests disclosed the existence of oxygen atoms of weights, 16, 17, and 18, respectively, and of carbon atoms having masses of 12 and 13, respectively. Not only do the new methods of analysis enable the atomic physicist to determine whether or not a given element is isotopic but also, in the case of elements which are isotopic, they provide data

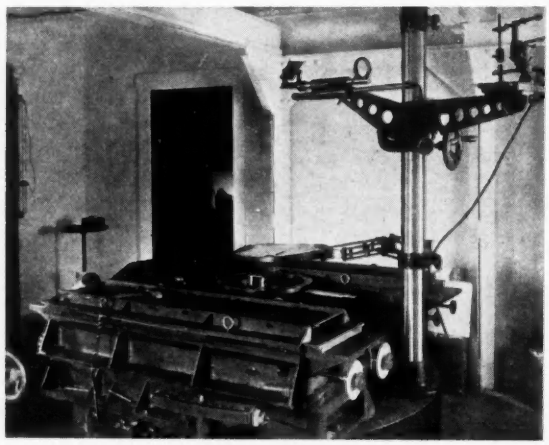


VACUUM ELECTRIC FURNACE.
By means of this furnace, which is part of the plant at Mount Wilson Observatory, substances are vaporized under close temperature control.

by which he can compute the relative abundance of each isotope. In the case of oxygen, measurement of the actual intensity of the band spectra indicates that the O_{16} atom is 1,250 times as abundant as the O_{18} atom; while calculations lead to the probability that it is 10,000 times as abundant as atom O_{17}.

Although study is being made of the relative abundance of atoms C_{12} and C_{13}, composing carbon, the results have not yet been announced.

To appreciate the significance of "isotopes" and their part in the development of chemical theory, we must glance back a little more than a century ago. At that time the observation was made that the atomic weights of all the elements then known, in comparison with that of hydrogen, taken as unit 1, were too nearly whole numbers to be the result of chance. This led to the suggestion that possibly all the elements were related to hydrogen in some way, perhaps as multiples or aggregates of the atoms of that element.



GIANT SPECTROGRAPH.
The upper end of the spectrograph used at the Observatory. Its weight of four tons gives it a high degree of stability. The electric arc is seen on the right.

While the approximation to whole numbers in every case was close enough to warrant the conjecture that each element had been built up of combinations of the hydrogen atom, yet actual tests, repeatedly verified in later years, showed that the atomic weights of many of the elements were quite appreciably removed from whole numbers. For example, it was found that the atomic weight of chlorine, measured in relation to the basic unit, was 35.457; that of potassium, 39.096. This apparent conflict with what was demanded by the very nature of atoms themselves was extremely disconcerting, until it was learned that many of the elements were actually isotopic mixtures.

Then the explanation became perfectly clear. The weight of chlorine, which it was thought should be a whole number, was beautifully explained when it was learned that chlorine is an element consisting of two atomic species, one of weight 35 and one of weight 37, mixed in proportions which give the element its average value of 35.457. Again, bromine comprises isotopes weighing 79 and 81, respectively, mixed in a way such as to give 79.916 for the element.

The successful attempt, therefore, to reconcile scientific observation and scientific theory, seemingly in conflict, led to the knowledge of a truth which otherwise might have resisted discovery for a very long time. The brilliant investigations of recent years point to the conclusion that the century-old guess that hydrogen was the primordial element out of which the universe is constructed was not far wrong.

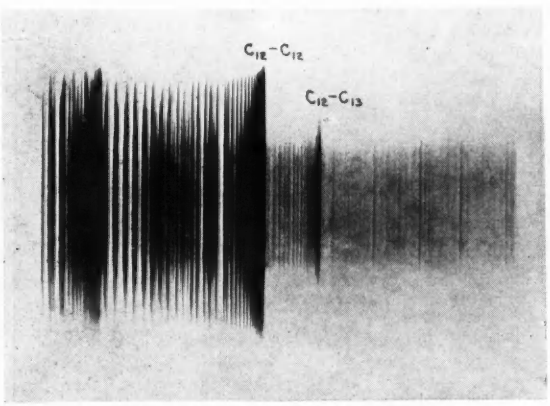
In order to understand the occurrence of isotopes—atoms of the same element but differing in weight—it is necessary to examine current views on the structure of the atom. At the present moment the so-called "Bohr atom," a model which suggests that a miniature solar system with whirling planets is comprised within the compass of an atom, occupies the centre of the stage. It is a useful model for, better than any before conceived of, it meets the tests of experimentation and observation.

According to this view the atom consists of an aggregation of positive and negative electric charges, related to one another in ways not yet fully understood. For some unknown reason, the positive charges, called protons, are much heavier than the corresponding negative charges, which are called electrons, about 1,840 times heavier, in fact. These protons, despite their mutual repulsion (like-sign electric particles always repel one another and unlike-sign particles attract) congregate because, mingled with them, there are a sufficient number of negative particles (electrons) to hold them together. In this manner a relatively massive nucleus is formed which determines the atomic weight of a given atom.

This nucleus, moreover, is positively charged because the electrons (negative charges) which it contains, while sufficiently numerous to hold the protons together, are too few to neutralize their combined positive charge. This deficiency is supplied by additional electrons which freely circulate around the nucleus, being bound to it, though not incorporated in it, somewhat as the planets are bound to the sun around which they revolve. The atoms of every element, therefore, according to this view, comprise a nucleus, made up of a definite number of protons

held together by a definite number of electrons, and an aggregation of planetary electrons, sufficient in number to establish exact electric balance.

Thus the atom of hydrogen, the simplest of all, consists of a nucleus of only one proton around which revolves one electron. Next in the series of elements is the helium atom, in which two electrons revolve around a nucleus four times the weight of the hydrogen nucleus. Then comes the lithium atom in which three electrons move around a nucleus having six times the weight of the hydrogen atom. And so by successive steps up the series of 92 elements, the number of units increases until extraordinarily complex aggregations are reached as, for example, in the atom of uranium, the last of the series, which contains 238 protons and an equal number of electrons, 92 of which revolve around the nucleus. Hence the latest view is that the entire universe, so far as knowledge of it goes, is built up, not of hydrogen as such, but of protons and electrons which, in their simplest possible combination, constitute the hydrogen atom. That is to say, the important conclusion has been reached that all the various forms of matter—carbon, hydrogen, oxygen, nitrogen, mercury, iron, silver, gold, and all the rest of the chemical elements—differ from one another only in the number and arrangement of electrons and protons.



SPECTRA OF THE TWO CARBON ATOMS.

In the relationship of protons and electrons within the atom lies an explanation of isotopes, which can readily be grasped in its application to the newly discovered isotopes of the oxygen and carbon elements. As already stated, the investigations at Mount Wilson Observatory have shown that oxygen consists of three isotopes having, respectively, weights 16, 17 and 18; and that carbon has two isotopes of mass 12 and 13, respectively. The arrangement of protons and electrons in each, according to prevailing theory, is as follows :—

Atom O_{16} consists of a nucleus of 16 protons and 8 electrons; and an outlying, planetary group of 8 electrons.

Atom O_{17} consists of a nucleus of 17 protons and 9 electrons; and an outlying group of 8 electrons.

Atom O_{18} consists of a nucleus of 18 protons and 10 electrons; and an outlying, planetary group of 8 electrons.

It will be observed that each isotope is in electric balance, having equivalent positive (protons) and negative charges (electrons). It will also be observed that all have the same number of outlying, planetary electrons, and that the only difference lies in the nucleus which, in each successive case, contains one proton and one electron more than in the isotope which precedes it. Inasmuch as the outlying electrons determine the chemical properties of an atom, while the nucleus fixes its weight, it is clear that these isotopes are identical in chemical behaviour and different only in weight. Similarly with the two isotopes of carbon—each has 6 planetary electrons, but in C_{12} the nucleus consists of 12 protons and 6 electrons; while in C_{13} the nucleus comprises 13 protons and 7 electrons. Here, again, the chemical behaviour of the two isotopes is identical, inasmuch as the number of extra nuclear electrons is the same. Their respective weights or masses, however, differ by one unit, as shown by the number of protons and electrons in their nuclei.

As regards the method of the research under discussion, a glowing gas or vapour emits a definite number of discrete waves of radiation, each having its own characteristic length. When these are sorted out by an instrument called the spectroscope and the spectrum photographed, the print shows a number of bright lines on a dark background. Each line is the image of the narrow slit at the receiving end of the spectroscope. Its position in relation to the other lines in the spectrum will tell the investigator what wave-lengths produced it. The spectra of the elements differ greatly; no two are alike. Some contain but few lines, others, again, contain thousands. In every case, whether the source of radiant energy be the electric furnace of terrestrial laboratories or the incomparably hotter furnaces of those celestial laboratories, the stars, every element represented in the radiation is revealed by those lines in the spectrum which it alone can make. Moreover, since it is possible to vaporize every known substance and

since the elements in the sun and in all other stars are already vaporized, the scientist, through use of the spectroscope, can investigate the chemical composition not only of the earth but also that of far-distant celestial bodies as well.

Under certain conditions, when two or more atoms approach near enough to one another, they may form a partnership called a molecule. Sometimes, however, a molecule has only one atom. The molecule gives a spectrum which, though fully as characteristic as the spectra of atoms, is yet quite different for it consists of very numerous lines, closely grouped into *bands*, and concentrated at certain points into conspicuous *heads*. The incandescent vapour of compounds invariably produces band spectra, and certain elements also may do so when in a molecular state as distinguished from the atomic state. It was through study of the band spectra of molecules of oxygen and carbon that the isotopes of these two elements were discovered.

The results of the work are of importance not only to chemists but also to astronomers. In the opinion of Dr. Adams, the discovery of the isotopic nature of carbon in all probability explains an astronomical phenomenon for which, hitherto, no satisfactory explanation has been forthcoming. It appears that there are certain faint stars, sometimes called "carbon stars." They are red and they have a temperature that is comparatively low. These stars are of such interest to astrophysicists that they have been studied by eminent scientists of several countries. Examination of the light of these stars with the spectroscope discloses a band at a certain point in the spectrum of some of them, as shown on the recording photographic plate, which no one could identify. Comparison of this band with the band produced by the C_{13} isotope, when a carbon molecule is heated in the electric furnace to a temperature of the order of 5,000° F., indicates that probably the previously unidentified stellar band is to be ascribed to the presence of this isotope of carbon.

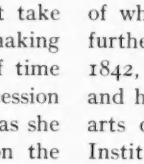
British Universities To-day: (6) Sheffield.

By Sir W. H. Hadow, C.B.E., D.Mus., LL.D.

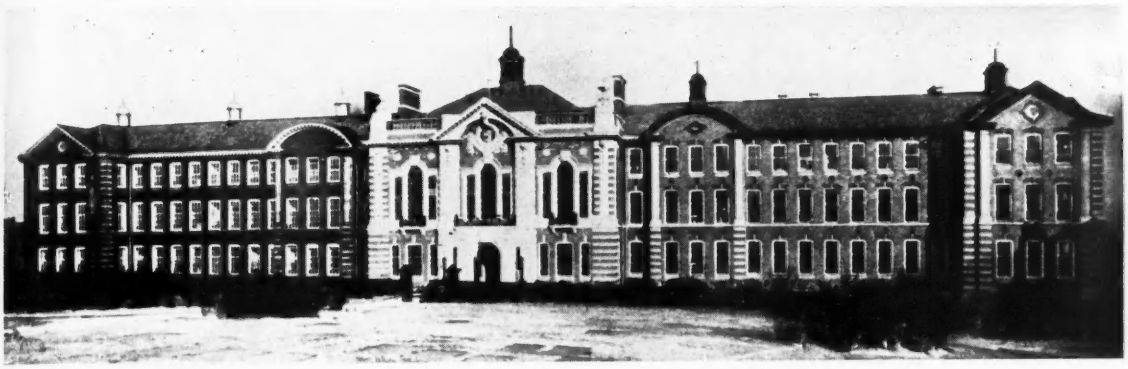
Vice-Chancellor of the University of Sheffield.

The modern universities alone can solve many problems of industrial civilization with which they are especially confronted. Close attention has been given to this subject for many years at Sheffield. Sir Henry Hadow begins by quoting a distinguished foreigner whose views on Oxford appeared in last month's article.

Professor Dibelius in his very interesting book on "England" has devoted some considerable space to discussing the constitution and problems of the modern universities as contrasted with those of Oxford and Cambridge. Many of these no doubt depend on tradition and on the mellowness which it brings with it; there is a true allegory in the answer of the Oxford gardener who explained the velvety smoothness of the college lawn by saying that "they had mown and rolled it for a thousand years." Beside this dignified and sequestered antiquity the municipal universities are still somewhat crude and unfinished—like new streets in a new city—and they must take comfort in the reflection that they are making traditions of their own; and that in course of time these will also be merged into a common succession and stand in the perspective as near to Oxford as she in her turn to Athens or Alexandria. And on the other side their very youth confronts them with problems of vital interest and supreme difficulty; problems of a democracy that is beginning to realize the value of education and to adapt to the newly-won knowledge its own ideals and requirements.



The first formal beginnings of the University of Sheffield may be dated from the foundation of the Firth College in 1879. This was established by Mark Firth, a wealthy and patriotic citizen, whose benefaction ensured for Sheffield a technological college of similar structure and purpose to those already founded by Owen at Manchester and by Mason at Birmingham. Before that time there had been in the city other educational organizations, all of which contributed in their several degrees to the furtherance of one policy, such as the People's College, 1842, which provided teaching in languages, literature and history, and may be taken as the nucleus of the arts department in the university; the Mechanics' Institute which, at the time when the Firth College came into being, had somewhat passed the days of its greatest prosperity; and a famous Medical School



THE DEPARTMENT OF APPLIED SCIENCE, UNIVERSITY OF SHEFFIELD.

which celebrated its centenary a couple of years ago and to which the medical faculty of the university owes its existence.

By 1874 a desire for advanced education in Sheffield had become urgent, and it was at this juncture that Mr. Mark Firth, at that time mayor of the city, came forward with the benefaction which rendered possible the institution named after him. The college was opened in 1879 and the next year, by the wisdom and forethought of the Sheffield School Board, a large central higher school was founded (the first of its kind in the country) with a full organization of evening classes in applied science. As a result of its success, and under the stimulus of the Royal Commission Report in 1881, a new technical school was founded in St. George's Square, and from this in direct succession follows the applied science department, to which the university owes so much of its success and reputation. The first stage of our history was completed when, in 1897, the three organizations of the Firth College, the Medical School and the Technical School were formally united, and the combined institutions raised to the status of a University College.

By this time the colleges of Liverpool, Manchester and Leeds had become the constituent elements of the Victoria University. The college at Sheffield applied for admission, but the feeling at the time was against federation and, in the course of a few years, this university broke into its three constituent elements, which became the University of Liverpool, of Manchester, and of Leeds respectively. Sheffield followed suit later. In 1902, after raising a considerable sum for buildings and endowments, it applied for a charter; this was granted, and the buildings of the newly constituted Sheffield University were opened by King Edward VII in 1905. Since that time its career has been one of consolidation and extension along the normal lines of the modern universities.

The university has always been closely connected with the city, for which, indeed, it has done a considerable amount of direct technological work, and to the generosity and co-operation of which it is deeply indebted. But it has always upheld as its chief ideals the pursuit of knowledge for its own sake and the development of character and citizenship. One of the most important functions which any university can fulfil is that of research among all such fields of enquiry as fall within its purview. In this matter all universities have a certain common ground, partly determined by their work of carrying to a further stage the customary education in arts and sciences current in secondary schools. It is clear that for this purpose the completest co-ordination possible should exist between the universities and the schools which lead to their doors; and, as such co-operation is most likely to be secured by common debate and discussion, the University of Sheffield has for many years established a Secondary Schools Council consisting of representatives of the university staff, of the secondary schools throughout the area, and of the various education authorities with which the university is connected. This meets periodically and discusses all borderland problems in which both the schools and the university alike are interested. The debates have been most valuable, not only for the sharing and comparison of opinions on important topics, but also for the promotion of sympathy and good fellowship between the different organizations concerned.

At the same time, although this common area lays before us the largest practising ground for the teaching functions of the university, it has also its high and important place in the world of research. It makes its own contributions to discovery in scholarship, in

science, in history, and in literature, and the teaching work itself is more efficacious because it is so often informed by the special skill and knowledge of the researcher. In addition to this common area which all universities share, there are certain special subjects to which they are respectively adapted with peculiar fitness, either from tradition or from the circumstances in which they live, or from the bias given in some direction by the genius of individual men. And so it follows that every university stands for some particular branch of knowledge shared at the most with one or two others, where conditions may be similar, and representing, at any rate, the distinctive part it plays in the world of education and learning. Sheffield, for example, has made a special study of steel metallurgy in one department, in another of pharmacology with special reference to diet, in another of the properties and use of radium, and in another of glass technology. In these, and in one or two others, it has its own problems to confront and its own regions of adventure to explore.

An encouraging condition of the university work is the variety and intimacy of its co-operation with other institutions, scientific, scholarly or industrial. Attention has already been called to the Secondary Schools Council. In the same way the university is generously supported by the local education authorities of the West Riding, of Derbyshire, of the municipalities of Barnsley, Rotherham, and Doncaster, and above all by that of its own city. Its medical work is done in close collaboration with the voluntary hospitals, and it is fully represented on the Joint Hospitals Council; it closely co-operates in the adult education movements of the region and is now establishing in connexion with some of these a system of broadcast education for which it has ample resources. Its department for the investigation of cold rolled steel, endowed by the generosity of the Ironmongers' Company, and equipped by that of the Cutlers' Company of Sheffield, opens a new prospect of activity which is full of promise for the future.

Trades Technical Societies.

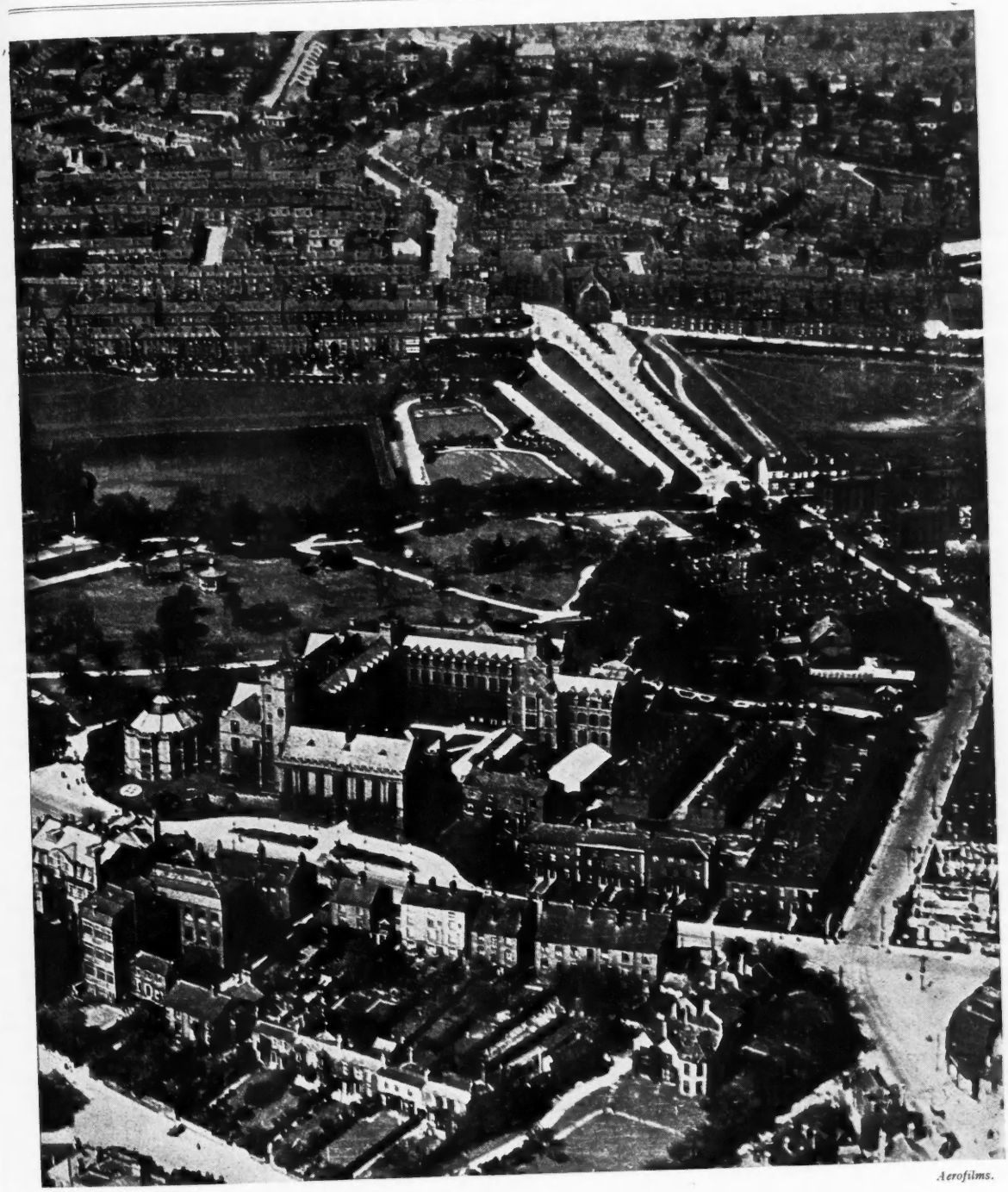
One of the most interesting experiments which has been made in this field is the organization of the Trades Technical Societies which, from being separate and isolated units with little of either common policy or common purpose, have been encouraged to meet together at the university for free discussion of their technical problems, and have accepted the invitation with such cordiality that the number of members associated is now over 1,170, and is steadily increasing. The Armourers' and Brasiers' Company presents every year £150 in prizes for discoveries made by workmen, and it is interesting to note that the competition for these is keen and the standard of attainment high.

Like all other universities, Sheffield lays great stress on the encouragement and furtherance of the social and civic life. It has not yet been able to carry out its full programme of hostel accommodation, but it has towards this one hostel for men and three for women, and it looks forward to a time when this side of its organization may be completed. The hostels at present are adapted private houses which, neither in size nor in construction, are perfectly suited to their purpose.

Corporate Life.

Hostels most suitably fulfil their function when they are specially built and when they have accommodation for not less than fifty students apiece. The number, in short, should be large enough to ensure an adequate corporate life within the walls and an adequate position as one of the constituent members of the university. It is worth noting, therefore, that although Sheffield has still some leeway to make up in this matter, it has considerably progressed during the last ten years, and it is contemplating further extensions at the present time.

Meanwhile the social and civic needs of the university are being met, as elsewhere, by a large number of societies and associations, academic and athletic; scientific, literary and artistic; some concentrated chiefly on reading and discussion, others extending more widely through social interests at large. There is probably no aspect of undergraduate life which cannot find some form of expression or take some place in the general policy. The chief need in this matter, after more ample accommodation for hostels, is a Union Building such as some modern universities now possess. The use that is made already of the buildings available is a sufficient indication of the full advantage which would be taken of a wider opportunity. It is a matter for regret that the university playing fields are three miles distant from the main building; but the topography of Sheffield, if there were no other reason, makes any closer contiguity impossible. They consist of over fifteen acres, well laid and in a good situation, and they have recently been supplied with a pavilion due to the munificence of the late Sir Albert Hobson. Among other contributions to physical education the university has built a gymnasium of which, as yet, only partial use has been made. It is proposed, as soon as possible, to take the necessary steps to bring it into full utility.



Aerofilms.

SHEFFIELD UNIVERSITY FROM THE AIR

The administration of the university has, like the British Constitution, grown rather by use and tradition than by adherence to a rigidly *a priori* scheme. The supreme authority rests with the Court, Council and Senate, under the last named of which are directly grouped the faculties, the discipline committee and the other departmental bodies which directly report to it. It has been found convenient, for certain special reasons, to arrange several aspects of the university work under governing bodies of their own. The growth of the university from the old technical school is reflected in the applied science committee, on which the industries of Sheffield are very largely represented and which, although it is technically subject to Council, has always, in fact, been allowed a large measure of autonomy. In like manner the mining committee is organized by an administrative body on which the chief colliery interests of the region are represented, and the department of glass technology is under a separate delegacy of its own, which comprises not only the chief glass manufacturers of the north but those of England at large. In this last case there is the special reason that Sheffield alone among the British universities includes such a department, and that it has always been largely and generously supported by the efforts of the principal manufacturing firms. The advantages of this federal scheme are that different departments, in the general organization of which practical experience of the industry is required, are enabled to bring that to bear in full measure on the academic skill and knowledge of the university.

A Remarkable Change.

One of the main obstacles to progress in the old days was a mutual want of co-operation—sometimes even mutual suspicion—between the teachers and the practitioners. The former regarded the latter as empiric; the latter regarded the former as visionary. It is well within living memory that the responsible heads of the great industrial firms looked askance at the young university graduates and preferred, openly and frankly, to select for appointment men who had been trained from the beginning in practical life outside. The very remarkable change that has taken place in this matter is due in part to greater enlightenment on the manufacturing side, in part to greater wisdom and flexibility on the side of the university, and almost wholly to the fuller opportunities of mutual co-operation—one might almost say mutual collaboration—between the two. And here the University of Sheffield has definitely ranged itself on the progressive side and has carried the principle of *cuique in sua arte credendum* throughout the whole of its educational field.

It is said that when Conington once momentarily left the fields of Latin scholarship for those of social economics he was charged with acquiring his knowledge of the working man by "a hasty generalization from his college servant." The modern universities see practical life in a wider range and with more comprehension; they know only too well how urgently questions of employment and livelihood may press upon their gates and how real and immediate are the needs which they are called upon to supply. I remember having to deal once with a disciplinary question in which it was not easy to assess the penalty. At Oxford the culprit would have been fined or gated and there an end. Both these were in the circumstances impossible; the one could not have been enforced, the other would have seriously overburdened the household. I consulted a wise professor who knew the ways of the place far better than I. After meditating for some moments on the most appropriate treatment of the offender, "I think," he said, "that I should exclude him from lectures for a fortnight."

The Pursuit of Truth.

Yet it would be an entirely false inference that the modern universities allow their courses to be determined, or even deflected, by the exigencies of a career; they proceed in an orbit of which the two focal points are the pursuit of truth and the development of character. Both these ideals the University of Sheffield, like its neighbours and colleagues, has followed with an undeviating loyalty. Indeed, it may be said that the keenness of apprehension and the tenacity of purpose which are among the virtues of the industrial north have themselves contributed to foster a scheme of education which sets the highest value on culture in the truest and widest sense of the term. One significant piece of evidence is to be found in the choice and treatment of subjects for our extra-mural work. These are selected by the classes themselves, not imposed or suggested by the university, and it is interesting to observe in how many cases their subjects lie in fields of art and of pure science rather than in those of industrial efficiency. So it is *a fortiori* within the walls of the university itself. The educational fabric which it exists to construct is built upon the solid foundations of knowledge pursued for its own sake and of character hewed from the quarries of social and civic life; in its house are many mansions, and it holds most in honour those which are devoted to furthering the spiritual welfare of all who enter in at its gates.

Virus Diseases of Plants.

By Kenneth Smith, D.Sc., Ph.D.

Potato Virus Research Station, School of Agriculture, Cambridge.

Virus diseases among plants are the subject of close investigation, not only because, by their wholesale destruction of crops, they cause heavy monetary loss to agriculturalists all over the world, but also because it is hoped that further research may help to throw light upon virus diseases in general.

Most people are aware that many diseases of animals and plants are due to the harmful activities in the host of minute organisms such as bacteria, fungi or protozoa. These organisms, although excessively small, can be seen by means of the microscope and can also be stained, cultured and otherwise dealt with. There exists, however, another type of disease the cause of which cannot, at the moment, be included in any of the above categories; these disorders, because of certain similarities of behaviour, are grouped together into a class apart, and are known as "virus" diseases. The behaviour of viruses differs from that of bacteria in particular characters which justify their segregation, and these will be briefly explained. If a fluid containing bacteria is passed through a porcelain filter, the fluid or "filtrate" which is obtained after passage through the filter is found to have lost its infective power, the organisms having failed to pass through the pores of the porcelain.

Fig. 1.
A STRIKING EFFECT.
A curious formation in a leaf, due to the presence of a plant virus.

In 1892, Iwanowsky, working with the "mosaic" disease of tobacco, and later Loeffler and Frosch with the virus of foot and mouth disease, showed that the fluid containing the infective principle of these diseases was just as infectious after passage through the filter as before, or, in other words, that the infective entity of the viruses was too small to be retained by the porcelain. This power to pass through a porcelain filter is characteristic of the virus group, and they are, in consequence, usually known as "filtrable viruses." Again, owing to the extremely small size it is not possible to *see* a virus, even under the highest power of the microscope, which is unable to resolve particles smaller than about one five-thousandth of a millimetre in diameter, although Barnard, by means of the "ultra microscope" using ultra-violet light, has photographed particles one twelve-thousandth of a millimetre in diameter. Another characteristic of viruses is the fact that so far it has been found impossible to culture them outside the plant or animal host, they seem only able to live and multiply within the living host cell, although certain plant viruses possess the power of remaining infective for long periods in dried plant tissue. The nature of viruses is not known: if they are living organisms, and many points in their behaviour suggest that they are, life must be capable of existing in dimensions much smaller than has been hitherto thought possible, since the size of some virus particles is considered to approximate to that of the molecules of certain proteins. It will be obvious that these characteristics of viruses, that is to say, the fact that they are below the limit of vision and the impossibility of culturing them on artificial media, render their successful study decidedly difficult.

Over one hundred virus diseases have already been described. Their ravages are not confined to plants, for they also attack animals such as insects, birds and mammals, and even man. Bacteria themselves, in fact, are not immune, since the so-called "bacteriophage" which destroys bacteria is considered to be a virus. Examples of well-known viruses affecting animals are foot and mouth disease, rabies, swine fever and distemper, while such diseases of man as yellow fever which is spread by a mosquito,

chicken pox, small pox, and influenza, are considered to belong to the virus group. Additions are constantly being made to this list, for example, Psittacosis or "parrot fever," which has been much to the fore of late, is now thought to be due to a filter-passing virus, and recent research upon the nervous disease "disseminated sclerosis" suggests that this also may be a filtrable virus.

The virus diseases of plants are probably quite as numerous as those of animals, and some are of very great economic importance. They are expressed in a variety of symptoms, such as variegation or yellowing of the foliage, rolling of the leaves, streaking of the leaves and stem, or in the formation of curiously regular concentric rings and patterns on the leaves (Figs. 1 and 2). It has recently been shown that the familiar "breaking" or variegation of tulips, which forms an attractive feature of that flower, is due to a virus which can be carried by an aphis, while the variegation in *Abutilon sp.* is thought to be of the same nature. The first virus disease to be discovered was the "mosaic" of tobacco (Fig. 3), which manifests itself in a bright mottling and spotting of the foliage; this disease is of serious economic importance in tobacco growing countries. Other important virus diseases of plants include, bunchy top of bananas, leaf-roll of potatoes, yellows of asters, mosaic of sugar cane, streak of maize, curly-top and mosaic of sugar beet, spinach blight, tobacco ringspot, mosaic of hops, and many others: the chief symptom of each of these diseases is indicated by its name. Some of the virus diseases which attack crops cause great losses annually. In this country chief significance attaches to the viruses affecting the hop, tomato, cucumber and potato; a reduction of over sixty per cent of a potato crop due to virus diseases is no uncommon occurrence. Indeed the so-called degeneration of this vegetable, which develops in crops grown year after year from the same "seed," is now known to be due to contamination with virus diseases.

Plant viruses are infectious and can be spread from plant to plant by inoculation, by grafting, or by the agency of insects. The actual degree of infectiousness differs greatly in various viruses; the least infectious can be spread only by grafting a diseased scion on to a healthy stock, as is the case with some of the infectious variegations, but others can be disseminated by all three methods. In nature, plant viruses are dependent, with a few exceptions, upon insects for their dissemination, and this interesting relationship is dealt with more fully later. Many viruses of the "mosaic" type, particularly those of the potato, can be transmitted by all the three methods mentioned, but the virus of potato leaf-roll, on the other hand, cannot be *inoculated* into a healthy potato plant, but can be transmitted by grafting, while in nature it is, of course, dependent upon an insect for its transmission.

In their mode of dissemination from plant to plant, the viruses show curious vagaries. Tobacco mosaic is a case in point; in some ways this is the most infectious of all plant viruses. It can be spread from plant to plant by a touch of a contaminated hand or knife, and owing to its power of remaining infective in dried tobacco leaves for indefinite periods, the disease is liable to occur in unexpected ways. In America, for instance, it was found that the mosaic was more rampant in some tobacco fields than in others, and it was noticed that the spread of the virus seemed to follow the movements of certain of the labourers. In every case such labourers were addicted to the habit of tobacco chewing with its concomitant habit of expectoration, the tobacco plants thus being infected either by the ejected tobacco juice or by the touch of contaminated hands. It is also apparently possible for tobacco plants to become contaminated with mosaic by persons who have recently been smoking or handling cigarettes and have then touched the growing plants. Again, the possibility cannot be excluded that the virus of tobacco mosaic may be living in certain sprays and insecticides containing nicotine, if these have been prepared in the absence of high temperatures. These facts are sufficient to show the infectious nature of tobacco

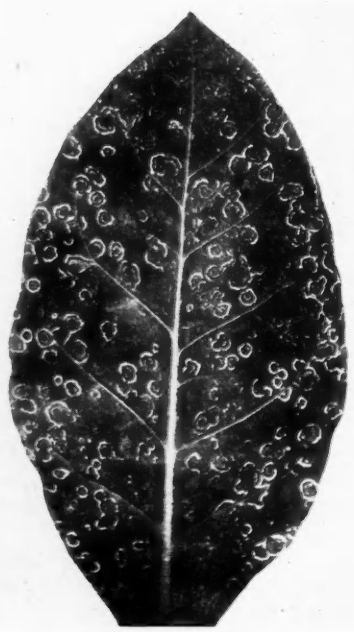


FIG. 2.
RINGSPOT VIRUSES.
The disease is frequently expressed by the formation o concentric rings.

mosaic, and it is therefore all the more surprising to find that the aphis *Myzus persicae* Sulz, an insect with an affinity for plant viruses, is apparently unable to transmit tobacco mosaic. If it is fed upon a tobacco plant containing a combination of mosaic and another virus, the aphis will pick up the other virus and leave the tobacco mosaic behind; there is presumably, however, some insect which does spread tobacco mosaic, but its identity does not yet seem to have been established.

The part played by insects in the dissemination of plant viruses is very important and, as already mentioned, many such diseases are entirely dependent upon certain insects for their spread in the field. The exact relationship of the insect vector to the virus, however, is little understood and offers a wide and interesting field for study. It may be suggested that there are two types of insect vectors, that in which the insect is a mechanical carrier only, *i.e.*, where the virus is carried on the mouthparts or contaminates the salivary fluid and is injected with this into the plant, and that in which there appears to be an obligate connexion between the virus and a particular insect species which alone can disseminate it. In the case of many mosaic viruses, which can be inoculated from plant to plant by the needle and which are disseminated by more than one insect species, it is fair to assume that such are examples of mechanical carrying only, but in certain other cases now to be described, where the virus cannot be spread by inoculation, it would appear that some obligate connexion exists between virus and insect. This is well illustrated by the work of Kunkel on "aster yellows" and its insect vector, a leaf-hopper, *Cicadula sexnotata*. This worker finds that a period of approximately two weeks must elapse between the time when the insects feed upon diseased aster and the time when they are capable of transmitting the virus.

In the same way the insect vector of potato leaf roll, the aphis *Myzus persicae*, does not become immediately infective after feeding upon a leaf roll potato plant, but appears to require a period of approximately fifty-four hours to pick up and transmit the virus from a diseased to a healthy plant. From some experiments conducted by myself, it seems that a non-infected aphis can become infective after six hours feeding on a leaf roll plant, and an already infective aphis can transmit the virus to a healthy plant after feeding on it for two hours. The whole process of picking up and transmitting the virus cannot be performed in eight hours, however, for a minimum period of approximately fifty-four hours seems necessary for this to take place. There are other instances of this waiting or "incubation" period of a plant virus within the body of the insect vector, and there thus seems some evidence of an obligate connexion between the two; if the existence of such a connexion is established by further research it will tend to support the theory that plant viruses are of a biological rather than a chemical nature. Another interesting point in the relationship of insects and plant viruses, and one which also supports the theory that such viruses are living, is the apparent affinity of a particular plant virus for a particular insect species which alone can transmit it. This condition of affairs exists in several cases; aster yellows is dependent upon a particular species of plant-sucking insect, the leaf-hopper *Cicadula sexnotata* for its transmission; spinach blight upon another leaf-hopper *Eutettix tenellus*, and streak of maize also upon a leaf-hopper, *Balclutha mbila*.

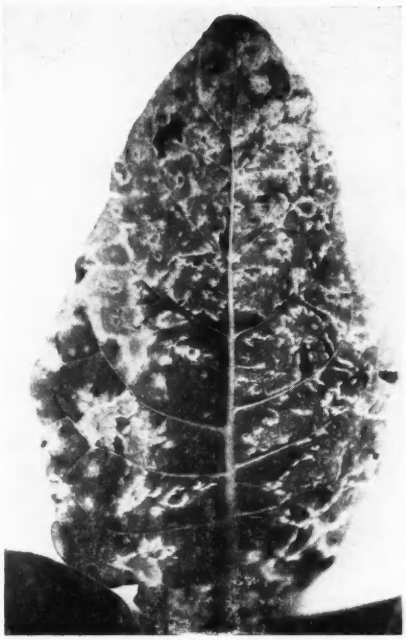


FIG. 3.
MOSAIC OF TOBACCO.
This disease, which manifests itself in a bright mottling of the foliage, was the first virus to be discovered.

Experiments at Cambridge have shown that an affinity, which may not, however, be so complete as in the above cases, exists between the virus of potato leaf roll and the aphis or greenfly, *Myzus persicae*, which transmits the virus with great regularity while other closely allied and very similar greenfly fail to do so. This restriction of spread to a particular insect species finds a parallel in the dissemination of malaria by one species only of mosquito. Another factor in this apparent relationship between the virus and its insect vector is the length of time which a virus-bearing insect remains infective without again having access to a source of infection; or, in other words, the length of time the virus will "live" inside the insect's body.

Kunkel has shown that the leaf-hopper, once infected, can retain the virus of aster yellows for periods ranging from forty-nine to seventy-five days, and, again, the insect vector of potato leaf roll, once infected with the leaf roll virus, has been shown to remain infective after feeding for seven days on an immune plant such as cabbage. All these facts thus briefly stated are rather in favour of the theory that plant viruses are living organisms, but it is, perhaps, better to defer this question until further research has made matters clearer.

Mention has been made of some of the external symptoms of virus diseases in plants, and it may not be out of place to describe briefly one internal symptom which is very characteristic of this group of disorders and which has been the subject of much investigation and controversy among plant pathologists in recent years. Microscopical examination of the hairs and diseased tissue of plants affected with virus diseases reveals in many cases the presence in the cell of what is known as an X-body. An X-body as it occurs in the leaf cells of a potato plant affected with mosaic disease is shown in Fig. 4. These bodies bear a superficial resemblance to organisms, particularly certain protozoa, and have been more than once described as such by some workers. The X-bodies are often of regular shape, vacuolated with an apparent body wall, and for a time the opinion was held by some plant pathologists that these bodies might be the causal organism of plant virus diseases and that they were capable of existing in a filtrable form. No one has been able to cultivate the X-bodies on artificial media, however, nor is there any real evidence to show that they are living organisms; indeed, recent research seems to prove that they are in reality a pathological effect of the virus on the cell cytoplasm rather than the causal entity itself.

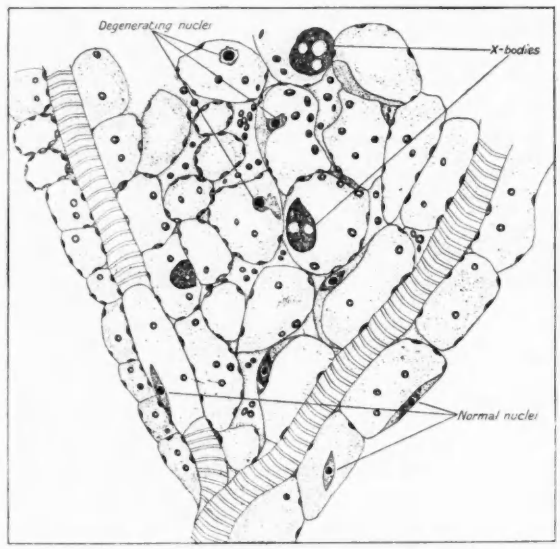


FIG. 4.
CELLS OF A POTATO LEAF AFFECTED WITH MOSAIC.
Recent research seems to prove that X-bodies are a pathological effect of the virus on the cell cytoplasm. (Diagram from *Annals of Botany*.)

In considering the relationship of the insect vector to the plant virus, the question at once arises as to whether the infecting insect itself presents any unusual or abnormal characters or is diseased in any way. Others as well as myself have examined microscopically by means of sections many virus-bearing aphides, without being able to detect any difference between them and virus-free individuals. Some recent work in America is of interest in this connexion; in studying microscopically the insect vector of the virus disease of sugar beet known as "curly top," it was found that the insect, a leaf-hopper, harboured two different kinds of micro-organisms. One of these, which would not pass a porcelain filter, was found in the bodies of both infective and virus-free insects, the other, which was capable of passing the filter, occurred only in the *infective* leaf-hoppers, but was also present in the diseased sugar beet, so that a possible causal relationship was suggested. Further developments of this interesting work must be awaited before any definite conclusions can be drawn.

Before concluding this brief sketch of plant viruses and their problems, mention must be made of the peculiar phenomenon known as "carrying." The reader is probably aware of the existence of the human carrier of typhoid fever and other diseases where a person, himself immune, bears the germs of the disease and is capable of infecting other healthy but more susceptible persons. The plant carriers of virus disease offer a parallel instance to this, and the phenomenon occurs most commonly in the potato and the hop. In the case of the former there may exist a variety of potato which appears to the eye perfectly healthy in every way and which will produce a normal crop of tubers, yet a scion from this plant when grafted upon another, and susceptible, variety of potato will infect the susceptible stock with one or more virus diseases which have been lying latent within the carrier plant. How far such a carrier plant is a potential source of danger in nature to other healthy susceptible varieties of potatoes or hops is not yet known, it depends upon

the capacity of the insect vector to pick up the latent virus in the carrier plant and disseminate it to other susceptible plants; precise information upon this point is at the moment lacking. It has been recently shown, however, that the common Solanaceous weed, "black nightshade," is such a carrier of potato viruses, and in this case the latent virus can be transmitted to healthy susceptible potatoes where it causes a virulent disease by the aphis *Myzus persicae*, which frequents both plants. It is important to differentiate between a carrier plant and an immune plant; in the former the infective agent is present though latent within the host, while in the latter the infective agent is unable to enter the plant, or having entered, is unable to develop or multiply.

An attempt has been made in this short account of the virus diseases of plants to present something of the importance of this type of malady which exhibits so many curious and interesting features. There are three aspects of this importance. There is the world-wide monetary loss arising from the destruction of crops by viruses. There is also the additional significance attaching to the control of insect pests, for although the numerical strength of certain insects and the extent of the damage which they cause may be negligible factors in agricultural economy, their capacity to transmit a plant virus renders them potent agents of destruction. The third aspect of the importance of virus diseases is the fact that a study of the viruses themselves may reveal the existence of a form of life hitherto unsuspected, and, moreover, because of their apparent similarity, further investigation may help to throw light upon some of the maladies which affect mankind.

Mineral Exploration from the Air.

By G. H. Blanchet, B.Sc.

Several companies have lately been exploring northern Canada from the air, to discover possible sources of minerals. The results were somewhat disappointing, but valuable experience was obtained in this new method.

THE building of the Hudson Bay railway directed the attention of business men to the regions bordering Hudson Bay for the development of which the new railway offered facilities. At the same time keen interest in mining activities drew attention to certain portions of the district which previous exploration had found to be favourable for the occurrence of minerals. Several companies were formed to undertake mineral investigations in northern Canada, commencing with the Hudson Bay area. These were the Northern Aerial Mineral Exploration, Dominion Explorers Ltd., and Cyril Knight Company. The Nipissing Mining Corporation of northern Ontario also sent prospectors into the district.

The various expeditions were organized on a very large scale. Ships and aeroplanes were purchased. Materials and equipment for elaborate bases were brought to points on Hudson Bay, and specialists in various fields, aerial, geological, and prospecting, were included in the personnel. The present article touches briefly on the operations of 1928 and 1929 and on the added knowledge of the country obtained through these activities. The complete report, with maps, will appear in a short time.*

The area considered lies chiefly in Keewatin District and includes most of it. The west coast of Hudson Bay was travelled from Churchill to Repulse Bay. Chesterfield Inlet and Baker Lake were navigated by the largest ship which had traversed them up to this time, and aerial observation was carried on over the greater part of the area. Many observations for latitude and longitude were taken and ground investigations were made at many points. Sufficient information was obtained to correct errors respecting the principal features on the map and to determine the general character of the country. It is difficult to realize the vast extent of the country involved. Keewatin District has an area of over 200,000 square miles, about the size of France. The Arctic watershed included covers about 35,000 square miles.

One of the most interesting aspects of these ventures into the Far North is that, by the use of the aeroplane for transportation and investigation, and wireless telegraph for communication, the boundary marking the generally accepted northern limit of resources was swept back a thousand miles into the north; country which had been unknown hitherto or had been seen only by the explorer on his rapid journeys across the country, was carefully inspected by trained experts from the air and studied in detail on the ground by prospectors fresh from the mining areas of northern

* Obtainable from the High Commissioners for Canada, Trafalgar Square, S.W.1.

Ontario and Quebec. The idea of aerial investigation for minerals, which is a comparatively new one, was given a good practical test. The possibilities and the limitations of the aeroplane in northern Canada were determined by the sound but costly method of practical experience.

Rock Observations.

The aeroplane first came into use in connexion with prospecting for minerals in the Red Lake area of northern Ontario and the Rouyn field of northern Quebec. Its earlier application was chiefly for transport—to reach points difficult of access quickly and easily. Prospectors and geologists flying across the country found that the aerial view was of great assistance in their ground work. Rock exposures can be readily located, and the general character of the rock can be ascertained from the appearance of the weathered surface. Sedimentary rocks can be distinguished from igneous and light basic rocks from the dark acid ones. It can be noted if the formations have been disturbed by igneous intrusions or by structural bending and folding. On the ground it may be a difficult matter to trace the course of an intrusive dyke, while from the air it usually stands out as an unmistakable line across the country with characteristic topography and vegetation.

When aerial photographs are available, especially verticals which can be studied in relief with the stereoscope, the country may be broadly classified as " promising " or " unpromising " for the occurrence of minerals. The most useful function of the aeroplane in this connexion is that of carrying a trained observer-geologist about the country, or of permitting the taking of photographs which may be studied by one. He is able to eliminate those portions of the country in which there are no rock exposures, or in which they are unfavourable for the occurrence of minerals, and to select promising areas. For this method to be sound it is necessary that the observer should be familiar with the local ground conditions, and that he should be experienced in aerial work. There are certain definite signs of minerals that may be observed from the air, chiefly what is known as " gossan cap " or a rusty brown stain of iron which may be associated with copper and nickel. However, more often the aerial observation reveals only general indications of formation and structure, suggesting the presence or lack of mineralization.

The next operation is to transport a ground party with supplies and equipment to study those areas selected as promising. Here, again, the aeroplane plays a useful part in placing the party quickly at any point within its range and providing local transport as required. Should the area prove interesting more men can be brought in, while, on the other hand, if nothing of value is found the party can be moved to another selected area.

The aeroplane can be used to a limited extent for one stage more. The tools and equipment necessary for the preliminary investigation of a mineral find can be moved in by it and service maintained until a fair estimate can be made of the discovery. Aeroplanes had been used for transport and observation in the mining districts mentioned, to a somewhat limited extent, previous to 1928, and both the executives and the field men of the mining interests had been satisfied with the services which they could render. When the possibilities of examining northern Canada for minerals came to be considered, the questions as to the difficulties that would formerly have been prohibitive, such as the vastness of the country and the short season of operation, were all met by the common answer—the aeroplane.

Elaborate Plans.

Work based on the extensive use of aeroplanes requires elaborate organization. The type of plane must be carefully selected and orders sent in a long time in advance of the required delivery. Gasolene bases must be established under the difficulties of northern transportation, and, as far as possible, spare parts and equipment must be carried to effect repairs in the field. At every turn practical difficulties are met which complicate the theoretical problem. There is a period in the spring and fall during which pontoons must be used in the south while skiis are required in the north. Conditions for mooring and landing are difficult on account of high tides, storms, and lack of land shelter. Then, too, the magnetic compass becomes first sluggish, and then useless, on account of the proximity to the north magnetic pole and conditions peculiar to the position of the compass in the aeroplane. The substitution of the solar compass is only a partial solution, as it requires comparatively clear skies. Other substitutions for the magnetic compass are too heavy to be suitable. The last resource for navigation—travelling by landmark—is not often feasible on account of incompleteness and inaccuracies of the map. Pilots are frequently faced by the difficult problem of travelling across country without a compass, without the sun, and almost without a map. A good instinct for location and a retentive memory are essential qualifications for a pilot in northern Canada.

When all the other difficulties and dangers of flying

in the north have been considered and more or less solved, there remains one that is the most baffling and feared by all who have experienced it. That is the condition of low misty clouds that hang over much of the country during the spring and fall. They are seldom more than 1,000 feet high, usually not more than 200 feet, and often have trailing curtains down to the ground. The pilot never knows how near the ground the mist may reach or what is the nature of the country beneath it. It is essential that this problem of spring and fall mist should be taken into account in planning all flying operations in the Far North. The organization for aerial investigation includes essentially the following personnel :— one pilot and mechanic for each plane ; ground parties comprising two prospectors each ; one geologist - observer for each operation. At the base one officer in charge directing the work and keeping records, a cook, and native casual labour. One aeroplane can serve three ground parties if scattered, and more if the parties are concentrated in one locality. There should always be at least two planes working from a base, one supporting the other but not necessarily working together.

A SURVEY IN PROGRESS.

Surveyors making sextant observations in order to determine their position. Ski-runners enable the aeroplane to land on the snow.

As regards the conclusions from the 1928-1929 mineral explorations, it is the general opinion of those who have been engaged in these operations that the west coast of Hudson Bay does not contain ore deposits of sufficient importance to be of present day interest. On the other hand, the promise of discoveries made and formations found in Mackenzie District point to that as being the field of chief interest. Although the results of the mineral exploration of the west coast of Hudson Bay have been unpromising, much useful information has been gathered on the country, the climate, the natives, and wild life.

In the course of the various flying operations opportunities occurred to observe the caribou migration in various parts of the country at the same season, and for the first time to get a comprehensive picture. It was previously difficult to determine what the movements actually were and whether the herds noted by various observers were distinct or the same ones in different stages of their migration. It is still impossible to form an estimate of their number but, to correct unsound generalities such as "countless numbers" and "the vanishing caribou," there are probably in the order of two to three millions, exclusive of those on the Arctic islands. The herds are lost in the vastness of the country, which could support much larger numbers. Good range land exists everywhere, there are many natural sanctuaries and the animals are only exposed to ravages of their enemies, man and the wolf, at certain seasons. It is probable that in those localities in which they are becoming scarce, the fact is that they avoid those places which they find to be dangerous.

The natives of the southern portion of the west coast of Hudson Bay are essentially inland people, depending on the caribou through much of the year for food and entirely for winter clothing. There appear to be local herds ranging between Churchill and Baker Lake which the Eskimos still meet at certain seasons at traditional gathering points. This country is favourable as a caribou range and the animals are comparatively unmolested. It is probable that they have changed little in number or habitat. The migration from the north-east which passes north of Baker Lake and reaches the upper Dubawnt River is less known. Recently they have been avoiding Baker Lake and hardship has resulted to the natives there, but in flying over the country to the north they were observed in great numbers, and later a steady movement was noted crossing at Aberdeen and Beverly lakes. These were chiefly cows and young, while large bands of bulls were seen to the south.

A much larger migration was noted passing the east end of Great Slave Lake about the same time, which was probably that seen by a number of observers there. At the time caribou were seen moving in a general trend towards the woods there were practically none in the Arctic coastal plains north of Back River. If these points can be established from the observations of those flying over the country, it will be of great assistance to the natives in directing their seasonal movements and in preventing the severe suffering during periods of migrational change.

Statues Found in the Sea.

By Stanley Casson, M.A.

Two remarkable statues discovered in Greece have now been restored and placed on view in the National Museum. Mr. Casson sends us from Athens the first photographs of the restored figures, which are of unique beauty. Their identity is not yet settled, but clearly they were lost in a shipwreck.

THE superb bronze statue of a god which was discovered two years ago in the sea near Artemisium, at the north end of the island of Euboea, has already called forth some little discussion. Photographs in various English papers showed the condition in which it was originally found, but only recently has it been mended, cleaned and placed on exhibition in the National Museum at Athens. As now exhibited it is clear that it constitutes not only the finest and most perfect example of a Greek bronze in Athens, but it can rank quite certainly as the finest Greek bronze in existence of the earlier periods of Greek art. For, after all, there are but a handful of original Greek bronzes of the sixth, fifth and fourth centuries B.C. There is the famous Charioteer at Delphi, the "Idolino" at Florence and two similar bronzes in other museums, and two fine bronze heads, the "Benevento" head in the Louvre and the similar head at Munich. All these are of the fifth century. Of the sixth there is the lovely "Piombino" bronze in the Louvre, of a scale about two-thirds that of life size, and there is the smaller Poseidon from Boeotia and a warrior's head from the Acropolis in the Aeginetan manner, perhaps the work of the sculptor Onatas, both now at Athens. But the new bronze transcends all these in excellence and some of them in preservation, for it is almost perfect.

The story of its finding is remarkable. Some years ago the fishermen off Euboea found obstructions in their nets. They drew up the arm of a bronze figure from a depth of about twenty feet. Later they decided to search for the rest, and in due course the other pieces were found. The two arms had been broken loose and both legs off, but nothing at all was missing except the eyes, which had probably been made of stone, and the object held in the right hand. The statue has now been most carefully cleaned and the loose limbs joined. The bronze has suffered no damage of any kind by its long immersion in the sea water; it has, in fact, acquired a particularly soft patination which in many ways is superior to earth-patinations.

The scale of the statue is very slightly above that of natural size. The attitude is of great subtlety and deserves a close examination. It seems to suggest a deviation from the ordinary athletic traditions of Greece and a reflection of something more stable and more archaic and, in effect, more hieratic. The figure is balanced lightly upon the ball of the right foot and the heel of the left. The right arm is loosely outstretched and held some object clasped in the fingers. The left arm, on the other hand, is taut and firm, with the fingers rigid and at full tension, as would be those of the thrower of a weight or a quoit. The body is just on the point of shifting its weight on to the left leg, in the process of hurling the object held in the right hand. This is no conjecture but the logical conclusion to be drawn from a study of the muscles and balance.

THE FATHER OF THE GODS.
The figure is slightly above natural size, and is a masterpiece of Greek art. It almost certainly represents Zeus throwing a thunderbolt.

This fixing of the centre of gravity down the spine and the centre of the body is, of course, a characteristic of most Greek

sculpture between the years 600 and 480. But the suggested change of balance, so subtly indicated in an older traditional stance, suggests one of the great sculptors of the period of experiment and change which followed the year 480 and led to the great achievements of the sculptors of Olympia. This figure thus falls into almost the same age as that which produced the Charioteer of Delphi, but whereas the charioteer is the work of a Sicilian artist, this bronze is pure Greek work, probably Peloponnesian. It is noteworthy, too, that the veins and sinews are clearly shown on the arms and hands, a characteristic which links it at once with the sculptures of Olympia and associates it with the period of Pythagoras, who was credited with being the first to emphasize these details.

The face and hair are as perfectly rendered as they are perfectly preserved and give us much information on the technical methods of Greek bronze-workers. Technically the bronze is of the first order, since the casting was so good that no subsequent patching was required. For all too often in ancient bronzes, small patches are found inserted in areas which had been disfigured by air-bubbles or similar blemishes. The features are stern and noble, with almost as much hint of archaism as in the Delphic Charioteer. The eyebrows are of inlaid silver, which remains undamaged, but the lips were not silvered at all. The very archaic character of the features gives it a stern and godlike quality. To look at it is to see the finest representation of any Greek god by Greek hands. And to look more closely is to see the Father of the Gods, Zeus himself. It has been suggested that this is Poseidon wielding his trident, but the statue seems to me, at least, to bear its own title upon its features. This is *Jupiter tonans*, Zeus hurling his thunderbolt, Zeus the destroyer and controller of destiny. Were he Poseidon he would be of another quality altogether, less inexorable, more approachable, as a glance at the slightly earlier Boeotian Poseidon will show. No Greek would have thought of this figure as Poseidon. And, if proof is needed, there is a numerous group of small bronzes of Zeus throwing his thunderbolt, which reach back in date to a time well into the seventh century. There are also coins which show various figures of Zeus in this same attitude. One, in particular, shows us a Zeus of this type by the sculptor Ageladas of Argos who worked in the early part of the fifth century.

THE CHARIOT BOY.

The second statue recovered from the sea. The boy clearly belonged to a chariot-group, where he perched precariously on the step of the vehicle.

It has been suggested that in this bronze we have an original from the hand of Ageladas, but this is a guess in the dark, for we have no evidence other than literary as to the work of Ageladas, and none at all as to his style. Pythagoras may rank as an equally good claimant, and there is a strong similarity between the treatment of the hair of the Zeus and the hair of an athlete which is by many critics attributed to that sculptor. But the matter must at present remain open and undecided, failing further evidence. What is certain is that we have in this bronze the finest Greek bronze and in many ways the finest example of Greek sculpture in existence, from the hand of a master of the most interesting period of Greek art.

With the Zeus was found the life-size figure of a small boy, in tense and vigorous action, clad in a thin garment called an *exomis*—the everyday work-dress of the average Greek. There was also found the head and fore-quarters of a horse, galloping at full speed. The boy and horse clearly belong to a chariot group of which the other horse or horses, the driver and the chariot are missing. The purpose of the boy would have been to perch precariously on the step of the chariot, and to guide it by shouting to the charioteer the risks and dangers which his control of the horses would not let him see immediately. The boy could prevent the collision with other chariots and warn in advance of stones and ruts in the road. The Charioteer of Delphi was helped by a similar boy, of whom some parts were found.

The boy is admirably portrayed and full of vitality and movement. He is a work of the late fourth or third century B.C., when naturalism was the sculptor's chief aim. He is like any Athenian urchin of to-day who, only too frequently, is taken by the driver of a long-distance motor-car to help in the repairs, or to sit on the mudguard and warn the driver, preoccupied with inefficient mechanisms, of impending dangers! In any case, he is no Periclean child with idealized features, but just a cheerful urchin. The remains of

the horse are of astonishing strength and power. The horse's head seems to me to be earlier in date than the boy, which would imply that the boy was an addition made at a later date by another artist to an already existing group. There is some evidence that this practice existed in antiquity. Works and groups were on occasions added to or improved.

Clearly these finds come from a shipwreck. The ship would certainly have been going from Greece and not coming to it. And, further, since the ship was leaving Greece from its eastern shores, its destination can hardly have been other than Constantinople, for there is no other imaginable destination for a shipload of various works of art than the city which Constantine was adorning with all the loot of the sanctuaries of Greece. The chariot group may, indeed, have been destined for the Hippodrome itself, where ultimately many such groups stood. In any case, it would be hard to think that the shipload was destined for Rome. If we knew which sanctuaries these works came from we might have some clue as to their authorship. But beyond the fact that the gulf of Lamia, near which the ship was wrecked, is conveniently near Delphi, we are left with mere guesswork.

Art through the Microscope.

By Albert Mann.

Biologists have long recognized the beauty of "diatoms," but these minute organisms have not been fully exploited by artists. To present this aspect of their study, an exhibition was recently held in Washington under Dr. Mann's direction. These remarkable objects are one hundredth part of a pin's head in size.

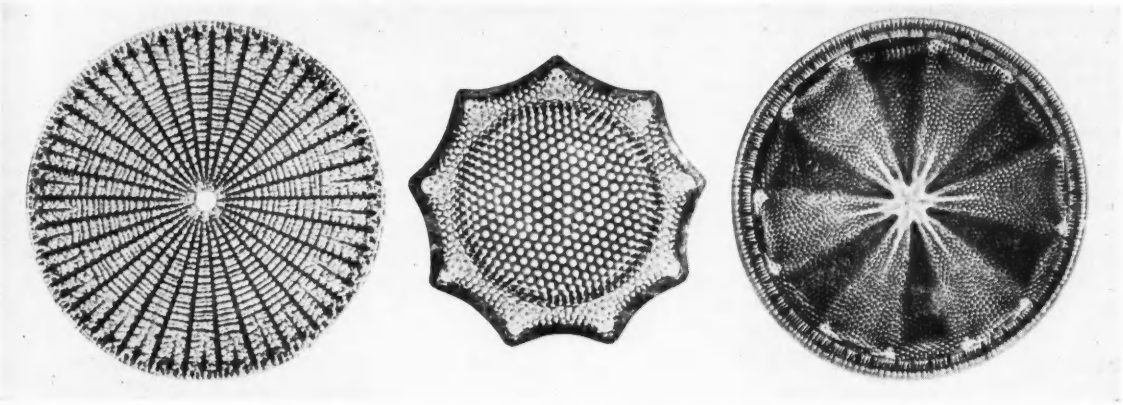
WHEN about a century ago the compound microscope was so far improved as to reveal with reasonable clearness the teeming forms of life which are invisible to the naked eye, a new world dawned on mankind; and among the first of its wonders that challenged man's thought was the beauty of the diatoms. He saw that in variety and grace of form these microscopic plants surpassed all the other organisms, and that, despite their diminutive size, they displayed in their ornamental designs such delicacy and complexity as had never before been seen. A great interest in their study was consequently awakened, and scientific journals began to be filled with accounts of new diatom discoveries and descriptions of their manifold artistic beauties.

As a result of this, improvements in the microscope quickly followed and it became an instrument of high precision. Men of wealth and leisure, especially in England, were found ready to pay opticians liberally for better instruments and more brilliant lenses with which to carry on this enthralling line of study. In fact, the diatoms not only became the chief incentive to improvement in the instrument by which they were revealed, but, because of the extreme delicacy of their sculpture, they were employed as the standard test-object for determining a microscope's excellence; and they are at the present day universally used for that purpose.

This general interest in diatoms continued unabated for many years, and not until the opening of this century did a new and more prosaic interest take precedence over their artistic attractiveness. The discovery of their value in certain processes of manufacture, and also of their importance as the basic food-material of all animal life in the sea, largely diverted attention from them as models of ornamental art. For twenty years or more diatom research, though more extensive than ever before, has been almost wholly concerned with their economic and financial worth. Doubtless this is as it should be; and yet inattention to the value of these remarkable objects as a source of suggestion for ornamental designing would be as actual a loss as that of some of the wealth now coming from their commercial uses.

With this idea in view, a display at the annual exhibition of the Carnegie Institution of Washington was especially arranged to illustrate "The Artistic Principle in Diatoms."

Diatoms are plants belonging to the group known as Algae. They are so small that one hundred or more would be required to cover an area no greater than that of the head of a pin. They occur the world over wherever fresh or salt water is to be found, but they are most abundant in cold latitudes. These tiny plants multiply with exceeding rapidity. Within the space of half a day each single-celled plant often divides in half, the two cells thus formed, in turn, produce four and so on. In the course of two or three weeks the numbers will have risen enormously. It has been estimated that in the waters of the English



SOME TYPICAL DIATOMS, SHOWING THE PERFECT SYMMETRY OF THEIR DESIGN.

Channel off Plymouth the annual yield of diatoms in the water layers beneath one acre of surface amounts to five and a half tons. In certain parts of the Antarctic the diatom ooze, most of which is rich in food materials, is frequently fifteen feet thick or more, and extends for thousands of miles as a band outside of the ice barrier. Dr. Nansen has recorded essentially the same great abundance of diatom life in the Arctic. However, the species of the two polar areas are quite different.

Such is the beautiful balance and interdependence which nature has evolved that just at the season when the diatom life of the sea is the richest, enormous swarms of small animal organisms of all kinds come into being and feed upon this great crop of drifting plants. These animal organisms, in turn, are fed upon by the fishes. Diatoms, therefore, may properly be said to constitute the fundamental food supply of the marine world, and so have been given the expressive appellation "the pasturage of the sea." The cell walls of these tiny plants are composed of silica, and so are indestructible. When the individual organism dies, as it does in a few days—for its life-span is very short—its glass-like encasement sinks to bottom of lake or sea. In this manner vast deposits, representing age-old accumulations, have been formed which, in turn, have been raised in many regions above the ocean level and thus made available for study. These shell-cases are among the most beautiful of all microscopic objects.

The value of diatoms as natural objects of highly artistic design is due to two things—their beauty of form, or what we may call their *architecture*, and the beauty of the ornamental patterns with which their outer surfaces are covered, or what we may call their *sculpture*. There are about eight thousand diatom species so far discovered, and the wide diversity they show in form is most remarkable. Hardly a known shape that combines grace of outline and symmetry of parts appears to be unrepresented by some diatom. Beginning with curved outlines, we find among them perfect circles of all sizes, others passing into oval, elliptical, crescent, serpentine, sigmoid, and other gracefully curved contours, with variations almost beyond number. In the symmetrical angular forms we have those with two, three, four, five, six, on up to over twenty angles, and having the sides between their angles straight or convex or concave or sinuous. All of them are so accurately proportioned and so faultlessly executed that they are the delight and the despair of any artisan who tries to copy them, whether for mural decoration or jewellery designs or textile patterns or other purposes.

Unique Beauty.

Their forms are further enhanced in beauty by various elevations or depressions in their surfaces, or by what we may call their *topography*, and these also are artfully arranged so as to give symmetry to the whole—flowing out wave-like from the centre or distributed evenly round the border. One can see, even by the crude imagery of these remarks, that in their diversity and elegance of form the diatoms as a class surpass any other living things. In surface ornamentation the artistic principle in the diatoms is even more strikingly displayed. The elements of composition in this surface sculpture, or carving, are very many, and are combined in such intricate and diversified ways that satisfactory description is practically impossible. In many species the surfaces

are covered with polished bars, straight or curved or both combined; others are adorned with beads in clusters or parallel rows, which may be straight or curved or undulating; others with delicate dusty particles or dots symmetrically arranged; others with feathery, plume-like tracery, like frost-work on a window pane; and many others in many other ways. One of the quite frequent ornamental devices used in a large genus of diatoms called *Coscinoaiscus*, meaning sieve-disc, is that of covering the surface with a hexagonal network of fine lines, like a delicate film of lace, which in certain species is radially arranged round the centre and in others arranged in criss-cross rows. This network is sometimes underlaid with delicate beading which adds to its beauty; in other cases the pattern is that of placing a single large polished bead in the centre of each of the hexagonal openings of the network.

It will perhaps add to our appreciation of the marvel of constructive skill expressed in diatom art, if we bear in mind that we are dealing here with an organism of extreme simplicity, a tiny plant made up of a single cell. Other objects in Nature of conspicuous loveliness secure their beauty of form and grace of parts by means of the co-operation of the millions of cells of which they are composed. The queen of the plant world, the rose, and the gem of bird life, the humming bird, gain their appeal to our admiration by means of hundreds of separate tissues laboriously brought into existence by millions of those working units—the living cell.

Single Cells.

The diatom, however, is but a single one of such units. Its vital portion appears to the eye as merely a microscopic droplet of protoplasm within which a globular particle, the nucleus, is suspended. Here are operating the machinery, the physics, the chemistry, of this master artificer, which takes from the water in which it lives the scanty supply of silica it contains and moulds and fashions it into the bewildering forms of beauty that have made it famous. That the laws of the sciences above mentioned are operative in this laboratory is unquestionable; but that this chemistry is diatom chemistry and not human chemistry, diatom physics and not human physics, is equally unquestionable. It is well for the aesthetic student of diatoms to hold fast to this point, which is in danger of being swept into forgetfulness by the tide of magnificent discoveries that the chemist and physicist are to-day bringing to our knowledge.

Another point bearing on diatom architecture and sculpture is the perfect control that this living plant displays over the raw material out of which it builds its fabulous palaces. It shows no trace of subordination to matter. The snow crystal, which is somewhat of a rival of the diatom in beauty, is bound and fettered in its designing by the laws of the substance of which it is composed. Water will crystallize only in a definite geometrical way. And therefore the ice crystal or snowflake must be built entirely upon the plan of three or a multiple of three. All of its lines must be straight, never curving. All of its subdivisions or branches must shoot out at a given angle. But the diatom handles its raw silica as a sculptor does his clay, moulding and fashioning it into the forms and fantasies which are the hereditary pattern of its kind.

A Mystery.

How a single cell can accomplish such results is and must long remain a mystery. Not only can the single cell carry out its artistic plan but, as is shown by many specimens in the diatom collection of the writer, such a cell, if interfered with by adverse outside forces, can build two designs of its hereditary plan instead of one. So that half a cell seems to have the power of the whole; and in an illustration Boyer shows a diatom where six separate centres of constructive skill have carried out the essential plan of its own species, thereby indicating that one-sixth of this microscopic cell is competent to produce the intricate design of the species. We deal therefore here not only with great beauty and diversity, but with a *sui generis* art which may be approached but is never equalled elsewhere in Nature.

The varied beauty of diatom carving is so great that it is idle to elaborate further; but it is perhaps evident from these remarks, aided by the illustrations that accompany them, that diatoms as a class offer a wealth of suggestion in the art of designing that is practically limitless. The full appreciation of this, however, can be gained only by a study of the diatoms themselves. Composed as they are of transparent silica, or crystal, they have a luminous beauty which no mere photograph or array of pictorial words can adequately express.

But the purpose of this article will be attained if it helps to call public attention to that somewhat forgotten phase of diatom study—their unique artistic beauty and the worth of it in constructive Art. Along with research in their significance as objects of Nature and of their worth for purposes of commercial use, diatoms equally well deserve the attention of thoughtful observers, both for the benefit and pleasure derived from any such aesthetic study and for the suggestive helpfulness they offer in the field of artistic designing.

Correspondence.

RATIONALIZATION IN BIRD MARKING.

To the Editor of DISCOVERY.

SIR,

In connexion with Mr. E. M. Nicholson's comments (April) on the responsibility of persons doing bird banding work, to the end that their activities be so conducted that there will be no cause for criticism upon humanitarian grounds, you may be interested in knowing something of the way in which we select our volunteer co-operators in the United States. As all migratory birds are protected under the terms of the Treaty between the United States and Great Britain, it is necessary for persons taking birds for any purpose whatsoever to be especially licensed by permits issued either from the Biological Survey or from the National Parks of Canada. As you will see, this gives us control over the operations of persons desiring to do bird banding work, and in considering applicants for the special banding permit we use every possible care to see that the person is not only thoroughly reliable, but also that he has sufficient knowledge of birds to identify accurately those that he might trap for banding purposes. Another requirement to which we adhere rigidly is that our co-operators must be at least eighteen years of age. In other words, we decline to make the banding work a plaything in any sense of the word, and we have repeatedly disapproved when scout masters and teachers have desired to take up this work as a means of giving instruction to children.

As indicating the extent of the banding activities in North America, I may say that at the present time our volunteer co-operators number about 1,700. The total number of banded birds is now about 600,000, and from these we have received about 40,000 return or recovery records. Our co-operative arrangements with Canada are excellent, and we also are receiving a constantly increasing number of returns from Latin America.

Very truly yours,

PAUL G. REDINGTON,

Chief of the Bureau.

Bureau of Biological Survey,
U.S. Department of Agriculture, Washington.

"THE TRUTH ABOUT PERSPECTIVE?"

To the Editor of DISCOVERY.

SIR,

I think the explanation of the uniformity of error in the result of the experiments undertaken by Mr. Thouless is explained by the *knowledge* of the actual dimensions of the objects of experiment militating against the judgment of their *appearance*. Thus a compromise has been struck, and here he is probably right when he says "It is as if the physical shape exerted a kind of attraction on the seen shape." A representation on such principles is not drawn as it is seen but as the observer *thinks* it is seen, and we may easily reduce this to absurdity by a comparison of the apparent relation of horizontal to vertical dimensions.

It is within the experience of every teacher of drawing that his students find the greatest difficulty in a reconciliation of these dimensions, this being known as the difficulty of "foreshortening." This difficulty is not overcome until the students have learned by experience that objects do not appear as they, at first, thought they did. I have had twenty years' experience of the drawings of children, and I do not find that they differ in error from the drawings of the untrained adult. They certainly contain that particular distortion which he points to as being correct, and this probably for the reasons I have given, but they also have many other errors which he would admit as such, conspicuous among them the divergence of receding parallel lines. Let us have done with this nonsense of lauding the so-called intuitive perception of the child. It is interesting enough as supplying a link in the chain of evolution of thought, but the child's perceptions are immature and unsound. Those of the adult are far from perfect, but he can, if he will, have the aid of the cumulative experience of a thousand generations. To part of this experience the child is entitled, and that is why we teach him.

Finally, let us admit that there is a tendency in "modern art" to abandon geometric perspective in favour of primitive or exotic traditions. The reason for this is probably a laudable desire for novelty and dread of satiety, coupled with a contempt of scientific learning and scholarship which are regarded (mistakenly I believe) as the enemy of artistic expression.

Yours faithfully,

S. G. BOXSIUS, A.R.C.A.

6, The Gables, N.10.

To the Editor of DISCOVERY.

SIR,

In his letter criticizing my article, Mr. Hughes points out that "The Yellow Chair" might be in mathematical perspective if the artist were sufficiently near to be well above the chair. That, of course, is exactly what I said about it originally. On second thoughts, I feel doubtful whether I am prepared to concede so much If the artist were sufficiently above the chair for the seat's perspective to be mathematical, I do not think so much of the back legs would be visible, unless the length of these in proportion to the depth of the seat were abnormally great. In any case, Mr. Hughes admits that the base of the bowl in "White Roses" is not in mathematical perspective, although his use of the word "correct" implies that he is not prepared to consider the possibility that any other method of drawing than in mathematical perspective can be right.

My argument was simply that it was more likely that the post-impressionists painted in accordance with the laws of psychological perspective than that they used mathematical perspective but habitually adopted a point of view which would give proportions unusual in the work of other artists. This conclusion is rendered very probable when we discover that the proportions they use are, in fact, the proportions in which we perceive inclined planes when they are viewed from a direction in which mathematical perspective would give the more conventional proportions.

We have, of course, two eyes. Therefore we must begin by investigating figures lying in horizontal planes in which the proportions of the projected figure will be the same for both eyes. In fact, the phenomenon I have described occurs also in vertical planes and when the figure is viewed with one eye only. When a figure is viewed with a single eye, the phenomenon is slightly diminished in amount through loss of cues to distance relationships. The complications arising from the different view points of the two eyes are quite unimportant because the phenomenon I am describing is enormously greater than the difference in shape between figures in vertical planes as seen with the two eyes. The seen shape of A in Mr. Hughes's diagram

would be much nearer to its true physical shape than would be its mathematical projection from the point of view of the left eye (which differs only very slightly from that of the right).

Mr. Hughes's criticisms do not touch the central point of my paper—that the way in which we see the apparent extensions of inclined surfaces is not in the proportions required by mathematical perspective, but in accordance with a law that such shapes appear to be intermediate between those required by mathematical perspective and the true physical shapes of the objects. This seems to be a sufficiently surprising result to merit the attention of those concerned with the practice of perspective drawing. The best way in which they can convince themselves of the truth or falsity of my results is by repeating my experiments.

Yours faithfully,

The University, Glasgow. ROBERT H. THOULESS.

A Lost Language.

THE language of the ancient Samnite tribe of the Paeligni, which was still spoken in the time of Caesar, is as yet known only from a few inscriptions discovered on the site of the ancient Corfinium about fifty years ago. It preserves some forms of early Indo-European speech more primitive than are recorded anywhere else in Europe; for example, the word *lexe*, "you have read," has an ending for which philologists have found no nearer parallel than in Sanskrit. Both in Europe and America students of language have long desired a complete investigation of this site, in the hope that fresh discoveries of inscriptions written in this dialect may clear up some difficult problems in the history of Latin and Keltic and the early stages of the European languages generally.

We have obtained Professor Conway's consent to print the following translation of a letter, which he addressed to Sig. Mussolini, and which has been published officially in Italy, proposing the resumption of excavations on this site. It lies in the heart of the Abruzzi, *i.e.*, the centre of the Appennine chain, near a village called Pentima.

To His Excellency Sig. Benito Mussolini.

In accordance with your kind permission I write to submit to you more fully the reasons which have led me to recommend cordially to your Government the enterprise of excavation in the rural district of Pentima, which still covers the ancient city of Corfinium. A certain amount of excavation was begun about 1878 by the late Antonio De Nino, the distinguished author of *Usi e Costumi Abruzzesi*, and the attempt was rewarded by considerable success; but want of funds and the complete absence of interest in such matters on the part of the Government of that day forced him to abandon the task a few years later.

Corfinium itself is closely associated with the career of Julius Caesar as the place of his first success in the Civil War in 49 B.C., where he exhibited for the first time his policy of mercy by dismissing free and without any conditions all his Pompeian captives, though they had occupied the town on purpose to bar his progress. It is very unlikely that any trace of this incident in the Dictator's life will be found in the remains still beneath the soil; but the site will always have the historical interest of having been the scene of this act of reconciliation, an act which, as everyone knows, had profound significance for the new epoch of the Empire.

But putting on one side such considerations of sentiment, the excavation of Corfinium is to be desired for scientific reasons which will have, I trust, due weight with the Fascist Government, whose enthusiasm for the study of antiquity has already produced remarkable, not to say astounding, results, at least for anyone who happens to be acquainted with the conditions that prevailed in many of the provincial museums of Italy forty or even twenty years ago.

Ever since I was a student in 1886 I have had a special interest in the Prae-Roman Dialects of Italy, and in the year 1894, when I was collecting the remains of these dialects in Central Italy with a view to the edition ultimately published at Cambridge in 1897, I found no visit more interesting than the days which I spent at Sulmona. There, guided by my revered friend De Nino, who, as I have said, was devoted to the history of the Abruzzi, I was occupied in reading the inscriptions of a language which had been entirely unknown before his discoveries, namely the language of the Paelignians, whom Horace and other Classical authors speak of as the bravest race of the Samnite stock. Those inscriptions have been found, if my memory does not deceive me, in only two trenches which had been cut across a burial ground representing the last two centuries of the Roman Republic. They were, and still are, only about twenty in number, and the greater part of them contain nothing but names; but the rest afford us valuable material for the study of the ideas and still more of the languages of Italy in the most formative period in its history.

The surface of this little centre of ancient life amidst the mountains can hardly, I think, extend over more than one or two square kilometres; and the remains are not buried beneath a mass of volcanic ash or tufa, nor do they lie under modern buildings. All that is needed is to uncover about a metre, here and there perhaps two metres, of soil under cultivation and easily handled.

We shall hardly find many beautiful objects of Greek or Etruscan art; but it may be said with confidence that there lie there not merely memorials of ancient country life, and perhaps of the local beliefs and customs of the Prae-Christian epoch, but also remains of a primitive dialect, whose forms, if only we can learn more of them from a larger number of examples, will certainly throw no small light on the most interesting problems of the history of the Latin language, and, indeed, of all the Indo-European languages. This is a service to knowledge which it is in the power of Italy, and Italy alone, to render.

My confidence in the importance of the discoveries that may be made is shared by two other scholars, the only two other living writers who have treated the Italic Dialects in any comprehensive way since 1890, Dr. R. Von Planta of Fürstenau (Canton Grisons), and Professor Carl D. Buck of Chicago. Professor Buck, when I was staying with him for a day or two last November, begged me warmly to do all I could to secure that the excavations in this area should be begun again, since a small part of it had already yielded such fruitful results.

If it were possible to begin regular excavations in the spring of 1931 I should count it a privilege to be allowed to be present there for a week or two in April or May, and to place my experience, for what it may be worth, at the service of those responsible for the undertaking.

Book Reviews.

Embryology and Evolution. By G. R. de Beer. (The Clarendon Press. 5*s*.).

This little book is from the pen of one of the younger Oxford men. It is an audacious attempt to prove that the life history of the individual throws no light on the past history of the race, or, as it is usually expressed, that "life history does not recapitulate an actual history." "Embryology," which strictly speaking denotes the study of the baby in the womb, is a term whose meaning has been extended to cover all sorts of development from the egg, whether that development takes place in the open, as is the case with the change of the tadpole into the frog, or inside a hard eggshell, as happens with the chicken, or inside the body of the mother as in a rabbit or in the human race. "Evolution" is the presumed gradual change of the race, as generation succeeds to generation.

The actual course of the life history can be discovered by investigation, but the course taken by evolution can only be guessed at. Hence it is a rash thing to say that evolution did not take place in the way suggested by the course of individual development because we have no *a priori* knowledge of how evolution did proceed, although we have three lines of indirect evidence to show how it *probably* proceeded. One of these is comparative anatomy of living animals, another is the study of fossils, and the third is embryology. Of these three, embryology is by far the most valuable because all animals begin their existence as eggs, whereas the fossil remains of only a few kinds of animal are known. Obviously the vast majority of the lower animals which have no hard parts at all can have left us no fossil remains, and only in the case of the Vertebrata, the group to which we ourselves belong, do the hard parts give an adequate idea of how the internal organs were arranged. The hard parts of the Arthropoda (crabs, lobsters, shrimps, spiders, scorpions, insects) consist of an external exudation which is periodically shed; it invests the animal closely, and reveals what its outer form was, but tells nothing about its internal anatomy. The hard parts of the Mollusca (snails, whelks, clams, mussels, oysters, cuttle-fish, etc.) are rigid shells covering part of the body—but the same kind of shell can shelter two totally different sorts of Mollusca.

Comparative anatomy is even more shaky ground on which to base conclusions as to the course of evolution. In a group of animals, one may *seem* to us to be more primitive than the rest; we assume that this one has stood still in evolution whilst the others have progressed, but this is theory and not proof. In the case of very closely allied animals we may be able to reach sound conclusions in this way, mainly because the, presumably, more advanced animal *resembles the presumably primitive one when it is young*, but this is, of course, tantamount to taking for granted that development or growth is a record of evolution.

In as few words as possible I shall now attempt to give a short account of why I believe that embryology is a shortened and blurred record of the history of the race, and of how and why Mr. de Beer attacks this belief. Animals, when examined carefully, fall naturally into great classes, the members of which are characterized by the same fundamental type of structure. Thus, all shrimps and lobsters have, broadly speaking, the same kind of shape and the same type of legs. But one group (the hermit-crabs) thrust the abdomen (tail) into an empty whelk or periwinkle shell. The tail is curved to fit the shell, and the legs are developed only one side. Yet these hermit-crabs, when young, have perfectly straight tails with legs developed on both sides like ordinary shrimps. We find the same thing in every group in the animal kingdom. The aberrant member of such a group, when young, is like the type. This principle is the stable ground for believing in the doctrine of "recapitulation"—the doctrine clearly enunciated long ago by Eimer—that new features are developed at the termination of growth, and that youngsters represent the original condition of the race.

De Beer attacks this doctrine by bringing forward a number of cases in which he thinks it clear that the ancestor cannot have been exactly like the young stage. Now everyone, including Haeckel himself, who originally propounded the doctrine of "recapitulation," admitted that the primary "memory" type of development could become modified by secondary factors which led to falsification and blurring of the record. But he, and all those who agree with him, maintain that, by studying the life histories of a large series of allied species, these secondary factors can be eliminated and the fundamental ancestral character of the record unmasked. Some of Haeckel's figures illustrating this point are very like those which de Beer gives to prove that the record of ancestral history does not exist. This part of de Beer's book is full of fallacies which show that he is not well-read in comparative embryology, but it would require a long and elaborate essay to expose them in detail.

The reason for de Beer's attack on "recapitulation" is this: If Haeckel is right, evolution has consisted essentially in the successive adoption of new habits by a race; these habits are begun only when the animal has arrived at a certain degree of size and strength whilst the old habits persist during its younger life. De Beer has espoused the theory that evolution has proceeded by sudden jumps or "mutations," like the "sports" which occasionally turn up in the farmyard or garden. He maintains that occasionally one of these "sports," which occur from no assignable cause, "chances" to fit the demands of the environment and survives. This is to all intents and purposes a revival of the doctrine of "special creation." Suffice it to say that this doctrine, however it may be supported by "brilliant" young Oxford men, finds no countenance with those really competent to speak on the subject of evolution. Our leading systematists, palaeontologists, and embryologists are all convinced that evolution has been "slow, functional, and continuous."

E. W. MacBride.

Human History. By G. Elliot Smith, Litt.D., F.R.S. (Jonathan Cape. 21*s*.).

Anthropology, the science of man, has so wide a field that it is inevitable that it should be studied departmentally in a very special sense. As knowledge increases, and the technique of each department becomes more highly elaborated, it is increasingly difficult for the anthropologist to treat of the broader problems of the science synthetically. In the present volume Professor Elliot Smith, the leader of the diffusionist school, aims at showing how the study of man's origin, development, racial differentiation and distribution may be brought into relation with the study of man's culture, social organization and religious beliefs from which it has been dissociated too frequently. The connecting link is, of course, the theory of diffusion.

It has often been pointed out that the theory of diffusion is no new thing in anthropological studies. Archaeologists and students of cultural anthropology, however much they have been supporters of the view that like elements in culture may, and often do, arise independently in different parts of the world, have, as a rule, recognized that development also took place by borrowing and by transmission. But Professor Elliot Smith and Dr. Perry, to whom this book is appropriately dedicated, have given precision to the study of diffusion by the application of certain conceptions such as that of the culture complex, which serve as tests or indications according to the way in which they are regarded, of cultural migration. The diffusion of Professor Elliot Smith's school, however, is a very different thing from the transmission of elements of culture, such as a particular type of bow, or other weapon, or of utensil, which the student of technology admits. It is, in fact, a whole complex of culture of which agriculture forms the base, which they hold spread over the world, with Egypt as its starting point.

In "Human History" the author has once more sketched the history of man and his civilization on diffusionist lines, but, as has been said, keeping prominently in view the relation between the physical and the humanistic sides of his study. The argument is kept on broad philosophic lines and stated with admirable lucidity. Specialists in the various departments will criticize details. It may be held that it is still premature to hold without qualification to the priority of civilization in Egypt, while excavation in Mesopotamia continues to reveal further vistas year by year without reaching the absolute beginnings. Even if, however, judgment be suspended on a point such as this, important though it may be, it must be admitted that Professor Elliot Smith in this book has made his ablest and most stimulating addition to the literature of his subject.

E. N. Fallaize.

Modern Sunlight. By Leonard V. Dodds. (John Murray. 7*s.* 6*d.*).

Of recent years the subject of sunlight, both natural and artificial, has occupied a prominent place in the popular press and the imagination of the public. There can be no doubt whatever about the general effects of sunlight in general and particularly in specific cases. In the treatment of rickets and tuberculosis it is probably the most effective therapeutic agent known to medical science. At the same time this new vogue is not without considerable danger, and too much emphasis cannot be laid on the absolute necessity for specialized medical control in all cases where sunlight, and more particularly artificial sunlight, is to be used therapeutically. The casual purchase of an ultra-violet lamp and its promiscuous use by the layman as a cure-all is to be whole-heartedly condemned. It is well known that in many cases serious symptoms have appeared as a result of such a course.

Mr. Dodds' book is a valuable contribution to the literature on this subject. Although it is the work of an enthusiast, yet it is conspicuously moderate in tone and of very great general interest. The author has obviously devoted a lot of time to searching out reliable facts in all branches of this subject, and his statistics are consequently informative. He discusses the application of ultra-violet light in health and in disease, and is impartial in his conclusions. He pleads very earnestly for immediate action in ridding the atmosphere in this country from smoke. The fact that such a plea is necessary in these enlightened days is very little short of scandalous. Soot and smoke in the atmosphere provide a perfect absorption screen for all the health-giving rays of the sun, and so constitute an alarming factor in infant mortality and adult debility. Legislation on this matter is imperative. It is to be hoped that Mr. Dodds' book will be read and remembered by those whose professed interest in social service is so clamorous at election times.

There are very interesting chapters on the use of ultra-violet rays on farms of all kinds and in veterinary work, and also a chapter devoted to industrial use of the rays. I have no hesitation in recommending this book to all who are interested in the establishment of health-giving conditions of life. It is a well written, non-technical epitome of the whole subject of sunlight and ultra-violet radiation.

V. E. Pullin.

John Franklin's Bride. By the Hon. Mrs. Gell. (John Murray. 15*s.*).

This unusual book affords an intimate glimpse into the domestic life of Sir John Franklin, the famous Arctic explorer, and Eleanor Anne Porden, his wife, and, incidentally, throws interesting light on the elaborate, and often amusing, etiquette which surrounded middle-class life in the early nineteenth century. The book, compiled by the wife of Franklin's grandson, contains the correspondence which passed between Franklin and Eleanor Porden, before and during their brief marriage, including a selection from the letters of their intimate friends and relatives. The brief contact of the blunt sea captain, "who was never at ease in society, who hated being lionised and to the end preserved a holy horror of London," with one of the most brilliant hostesses in town, "when London stood for all that was most choice in the literary, artistic and scientific world," is traced from early friendship, through the qualms and reassurances of betrothal, to wedded life and parenthood.

The explorer seems to have been a poor correspondent, for Eleanor's letters are well in the majority and are considerably more copious than those which Franklin wrote to her. With characteristic reticence, Sir John makes little reference to the expeditions upon which he was engaged from time to time. In a letter from his ship *Prince of Wales*, while returning from an expedition to North America, he wrote: "I presume my dispatches have reached England at least a month since and that the information has already appeared in the newspapers. You know the injunction of silence we receive until the means of opening the communication has been expressed, and you will see the necessity of my abstaining at this time from giving you the intelligence regarding our voyage I should wish." The author of the book, however, supplies the information which Franklin's modesty forbade him to disclose, and in her admirably explicit notes describes the expeditions which he undertook and the discoveries which he made. An interesting sidelight on contemporary research in magnetism is included.

Unfortunately, the romance of Sir John Franklin and Eleanor Anne Porden was brief. Eighteen months after their wedding, the explorer's wife died of tuberculosis. Her letters were found, after Franklin's death, in a packet among his papers, labelled in his own hand: "Letters received from my dear wife Eleanor. To be given to my daughter. J. Franklin."

The North Pole of the Winds. By WILLIAM H. HOBBS, Professor of Geology in the University of Michigan. (Putnam. 21*s.*).

It is possible to-day to forecast the immediate weather outlook with reasonable exactitude, but absolute accuracy has not yet been attained, nor will it be until an efficient system of meteorological stations has been established in the regions of the Arctic. It is in the establishment of such observatories that Polar exploration will undoubtedly play an important part. Already the discoveries of Arctic explorers have proved invaluable to meteorologists, and the investigations of Professor Hobbs himself have led to the establishment of the first important Arctic weather observatory. As Professor of Geology in the University of Michigan, the author of this book has led three expeditions to the Arctic for the purpose of setting up an aerological station on Greenland, the North Pole of our wind system. This book is a detailed account of the three journeys, and as a travel book it is moderately interesting, though not more so than most other books of its kind. Its chief value lies in the meteorological information which it contains, although one could wish that more space were devoted to scientific data and less to descriptions of personal experiences which are not particularly interesting or remarkable. For example, "On the early morning of 1st July, as we lay in our bunks, the bell rang to stop the engines. This was soon followed by the signal 'half speed ahead,' followed by frequently changing orders." Such an incident would be commonplace on a ferry-boat from Portsmouth to the Isle of Wight.

One chapter is devoted to a description of the rescue of the Arctic fliers, Hassell and Cramer, whose machine was wrecked on the northern wastes. A faint column of smoke was detected rising from a point on the horizon. Members of the expedition immediately made for the spot in a motor boat in the hope that the smoke column was a signal from the missing fliers. The seas were running high and the small craft "rose and fell like a cockle shell on the giant waves." As the rescuers approached the point where the smoke had been seen a figure clothed in caribou skin was detected, and soon after a second figure, wearing a pakta, appeared. There was a wild waving of arms, and Etes, a member of the expedition, suddenly cried "Fish!" Etes and "Fish" Hassell were old friends, and the incident is described as a moving one. To the flippant it may, perhaps, have its humorous aspect. The spectacle of a man, clad in a caribou, violently waving his arms and crying "Fish," must surely be unusual even in the Arctic regions.

The Effect of Span on Aircraft Performance. Presented by the Director of Scientific Research, Air Ministry. (H.M. Stationery Office. 1*s.*).

This report is the outcome of research undertaken by W. G. Jennings, B.Sc., in collaboration with Messrs. Boulton & Paul, Ltd., and presented by the Air Ministry. The performances of three aeroplanes of the same type, of about 9,000 lb. total weight and incorporating wings with spans of 60 feet, 70 feet, and 80 feet, respectively, were calculated and the results compared. The machines were assumed to carry the same load. From the results of the performance calculations, it would appear that at low altitudes little change in performance is to be expected by increasing the span from 60 feet to 80 feet for this type of aircraft. At high altitudes, however, the larger span improves the performance appreciably and a marked increase in absolute ceiling is obtained. At all heights the maximum range of the larger span is considerably greater than that of the smaller span aeroplane. The calculations also indicate that the optimum span for performance at high altitudes would be appreciably greater than 80 feet for this type of aircraft, the average figure being 17 per cent greater. A relatively poor performance at low altitudes would, of course, accompany such a large increase of span.

The above estimate of the effect of span on performance is based on the assumption that the extra structures other than wings of three aeroplanes, designed to the same specification and incorporating the three given sets of wings, will be in such a form that they will have no influence on the relative performances. Also the assumptions that enter into the method of performance prediction from design data only (*e.g.*, interference effects, etc.), may modify to some extent the above conclusions. It is considered, however, that the above effect on performance is an indication of what may be expected when the span of an aircraft of this type is varied, and this is substantiated by detailed consideration of a number of matters dealt with in appendices to the report.

Science and the New Civilization. By ROBERT A. MILLIKAN. (Scribner's. 7*s.* 6*d.*).

The Romance of the Machine. By MICHAEL PUPIN. (Scribner's. 4*s.* 6*d.*).

It is always a pleasure to read a book by Professor Millikan. There is a breadth of learning and a freshness of treatment in his work that confers a delightful piquancy on the most hackneyed of scientific topics. He could even write a popular dissertation on the long suffering subject of Relativity that could be read, not only without nausea, but with positive pleasure.

This book has many original ideas, and is open and fearless in its defence of science against those mawkish sentimentalists, who, from the abyss of their ignorance, seek to condemn progress, chiefly for want of something to say. I was particularly pleased by Professor Millikan's vindication of science as the most powerful agent in the abolition of war. After a masterly description of the supreme value of scientific progress in the march of civilization, he says: "The nations of the world are forced by the advances in modern science to find some other way to solve their international difficulties. *Sentimental pacificism has nothing to do with it, it is a hindrance rather than a help.*" The italics are mine, but the author should have used them.

There seem to be two classes of the general public who take a profound interest in science. Those who cherish misgivings lest a scientific era should come to destroy all beauty, religion, and handicraft, and on the other hand there are those who look forward with certainty and pleasure to a mechanized and scientific world where everything will be achieved by pressing a button. Both schools of opinion are ludicrous. Professor Millikan deals admirably with both of them; he shows how science has not come to destroy, but to fulfil, and how the sublime law of universal order has a beauty, which in its fullness, transcends everything in the old scheme of things that was founded on ignorance and darkness. It stands for the triumph of reason over superstition. As the author so truly says: "The new God is the God of law and order, the new duty is to know that order and to get into harmony with it, to learn how to make the world a better place for mankind to live in, not merely how to save your individual soul." The awesome mystery of nature

first perceived and marvelled at by the great Newton, and gradually unfolded more and more by such men as Harvey, Faraday, Pasteur, Röntgen, and Einstein, reveals no button-pressing universe, but rather a world where men shall be held together in the exercise of reason, and reverence for the mighty origin of universal harmony.

It is a little difficult to describe this book; it is not "popular" science in the sense that we have learnt to understand the term, but it is perhaps better described as an authoritative, readable, and absolutely up-to-date treatise on the significance and effect of modern science. It is essentially a book that will be enjoyed by all thinking people whose outlook is undimmed by the stifling atmosphere of bigotry and mumbo-jumbo.

Of the second book under review I would say *homo potest esse habilis et inhabilis diversis temporibus* because Professor Pupin has in the past contributed greatly to the advancement of telephony. His new book, which appears to be a somewhat extravagant defence of science, or rather of American science against some unnamed "European Writers," is full of assertions. We are told that American scientists see in the development of rapid communications the guidance of a guardian angel who has watched over the destiny of that nation from its very beginning. . . . The statement, like others in the book, may be true, but it has chiefly a domestic interest. To read this volume all through is an achievement, it has 111 small pages.

V. E. P.

Forest Life and Adventures in the Malay Archipelago. By Dr. Eric Mjöberg. Translated from the Swedish by Anna Barwell. (George Allen & Unwin. 12*s.* 6*d.*).

Dr. Mjöberg, a Swedish naturalist, here gives his readers the results of eight years' observation among the wild life of the forests of Borneo and Netherlands Indies—lands which, perhaps, with the possible exception of Java, are not too well known to the English reader. Borneo, however, receives the largest share of the author's attention, which is only natural in view of its profusion of the material which was the subject of his study. In this island alone he covered 1,750 miles. His interests are catholic, for he deals with the forest fauna, from the anthropoids down, the forest itself with passing attention to its economic products—rubber, tobacco, coffee, tea, etc.—and he devotes a chapter to that botanical curiosity the giant *rafflesia*. One chapter, characteristic as an expression of patience and perseverance in research, is devoted to the discovery of the true nature of the so-called "trilobite" larva, a puzzle to coleopterists for a hundred years. As a description of life in a tropical forest, Dr. Mjöberg's book is of intense interest, if its style is somewhat pedestrian and too much like that of a notebook.

The Hong Kong Naturalist. Vol. 1, No. 1. January, 1930. Edited by A. H. Crook and G. A. C. Herklots. (Newspaper Enterprise Ltd., Hong Kong. 10s. per annum.)

We have just received from China the first number of a new illustrated quarterly that will deal principally with Hong Kong and South China. It is issued by two members of Hong Kong University, Mr. A. H. Crook and Dr. G. A. C. Herklots, and the subscription is ten shillings a year. The second editor, it will be recalled, contributed to *Discovery* last summer, when he described a visit to Krakatau made by members of the Pacific Science Congress. There is ample scope for the new magazine, as many factors of natural history in Southern China are so far unrecorded. It is believed that no coloured plates as yet exist of the flora and fauna of Hong Kong, with the exception of butterflies, which are found only in a volume many years old and now out of print. In the same way, very little has been written about the fish of the China Seas. A series of articles by Mr. H. W. Fowler will form a summary of present information on this neglected subject. The Hong Kong government has made a grant to the Editors, to provide coloured plates of the local birds in their first volume. All students of natural history will wish success to this enterprising production.

Popular Research Narratives, Vol. III. (Bailliere, Tindall & Cox. 4*s.* 6*d.*).

X-Rays. By B. L. Worsnop, B.Sc., Ph.D., Lecturer in Physics, King's College, London. (Methuen. 2*s.* 6*d.*).

This collection of narratives is most interesting. It consists of some fifty short descriptions of important scientific achievements, each one written by an acknowledged expert. They are not discursive, but plain accounts of the subject. They include such diverse matters as popular cinematography (by Dr. Kenneth Mees), the hardening of copper, and a description of the gyro compass, not to mention the measurement of such minute distances as one-billionth of an inch. It should have a large sale. It is apparently the third of such volumes, which suggests that the series is a popular one.

The second book belongs to Messrs. Methuen's excellent series of science monographs. This one is written by the general editor of the series. It is primarily designed for advanced science students, who have not studied X-rays as a speciality. It is an excellent short account of the subject, and the amount of material which the author has succeeded in covering in his ninety small pages is prodigious. It is not a text book, it is too scrappy, nor is it by any means a popular book, but it does achieve its purpose. It supplies an accurate résumé of the present position in X-rays. These little books should be invaluable to science students and school science-masters.

Early Navigators and their Voyages, Log Books, etc. Catalogue No. 525. (Francis Edwards.)

The sole existing manuscript describing the death of Captain Cook is among the many valuable accounts of early navigators and their voyages contained in a catalogue just published by Francis Edwards, Ltd., of 83 High Street, Marylebone. This manuscript is the original log book of Henry Roberts, officer-in-charge of the pinnace in which Captain Cook went ashore for the last time. The log, unknown until recently, consists of 144 pages, and contains six original charts bound in original sheepskin. It commences on 4th October, 1778, when the expedition was off the coast of Oonalaska, and ends on 30th November, 1779. The price of the manuscript is £2,000.

The "Atlantic Neptune," published in 1780-1 for the use of the Royal Navy, is also for sale at £1,150. The title is engraved, there are four sub-titles, a preface and general remarks, four leaves of contents and two leaves of references. The contents also include 140 large scale sheets of charts, maps, plans and views, many tinted or coloured, and some with coloured inset views. The whole is in two volumes, imperial folio.

Over five hundred other books on shipbuilding, marine atlases, original log books, paintings and accounts of early voyages are listed in this valuable catalogue.

ern China
red plates
with the
a volume
way, very
A series
of present
ng Kong
e coloured
tudents of
roduction.

Tindall &

cturer in
6d.).

t consists
c achieve-
They are
ey include
. Kenneth
the gyro
h minute
ve a large
h suggests

llent series
ne general
advanced
speciality.
ne amount
ing in his
book, it is
ut it does
ésumé of
should be
ers.

Catalogue

of Captain
navigators
olished by
one. This
officer-in-
ashore for
consists of
in original
when the
ends on
£2,000.
the use of
engraved,
narks, four
e contents
plans and
oured inset

ine atlases,
y voyages